STATE AGRICULTURAL COLLEGE

Fort Collins, Colorado

COLORADO AGRICULTURAL EXPERIMENT STATION

PUBLICATIONS OF 1906

The Agricultural Experiment Station

FORT COLLINS, COLORADO

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REPORT

Annual Report for 1906.

STATE AGRICULTURAL COLLEGE

Fort Collins, Colorado

COLORADO AGRICULTURAL EXPERIMENT STATION

PUBLICATIONS OF 1906

Bulletin 107. **February, 1906.**

The Agricultural Experiment Station

OF THE

Colorado Agricultural College.

PEACH MILDEW

By O. B. WHIPPLE

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

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PEACH MILDEW.

By O. B. WHIPPLE.

The phenomenal growth of the peach industry in that part of Colorado west of the Continental Divide is due, to a certain extent, at least, to the absence of insect pests and fungus diseases. While it is probable that our growers will never have the large array of these pests, which are common in many other regions, to contend with, we cannot hope to be entirely immune from such attacks. From a business standpoint, then, we should be constantly on the lookout for anything in the nature of a pest, so that it may be studied and means devised for its control before its attacks become serious.

Peach mildew has made its appearance in a few orchards and appears to be spreading. While no great amount of damage has yet been done, some of the growers are beginning to spray their trees for the control of the disease.

It is the purpose of this Bulletin to point out the nature of the disease and describe some of the means of combating it which have been used in other states. The Experiment Station has had no opportunity as yet to conduct experiments of this kind, but there is no reason to suppose that these remedies will fail in Colorado if properly made and applied.

The injury in Colorado is due to a fungus which attacks leaves, twigs and fruit alike. It appears on the fruits while they are yet small and immature, often causing them to fall prematurely. Its first appearance is indicated by a musty or frost-like patch upon the surface. When well established, the spots become almost pure white; the color being due to the mycelium and its fruiting branches, which overrun the surface upon which the fungus establishes itself. The flesh of the fruit becomes hard under these spots and the skin takes on a brown or dead color. The appearance upon the twig is very much the same, it being very conspicuous as white blotches along the twigs; the underlying bark becoming dry and brown. Where the attack is very severe the leaves fall, the bark becomes shriveled, and the young tips often assume a curved position. It

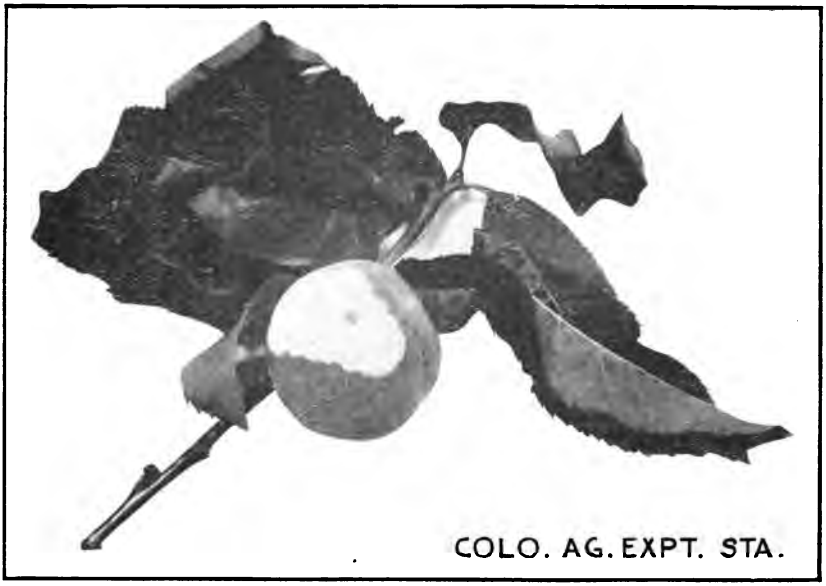

PLATE I.—SHOWING PEACH ATTACKED BY MILDEW.

PLATE II.—PEACH TWIGS ATTACKED BY MILDEW.

only appears on the current year's growth, it being able to establish itself upon the more tender growing parts only. On the leaves, it generally appears upon the under surface, most prominently along the midrib as white, irregular blotches. The attack is not confined to the under surface of the leaf, but is found there more often, probably because strong sunlight is its worst enemy. The leaves become crimpled and curled, the younger ones near the tip often falling during severe attacks. The tissues of the leaf are deadened, and it folds more or less along the midrib, the upper surface folding upon itself.

Attacks of this fungus often injure the fruit, in some cases almost ruining the crop for market. The young twigs are checked in their growth, and sometimes killed outright, while the foliage is greatly reduced. If no injury to the crop is experienced during the season of attack it is no doubt true that the future crops and good health of the tree are at stake. Fruit buds for the coming year cannot be developed on half-dead twigs poorly nourished by a scant supply of foliage. Neither is the tree in shape to withstand other troubles to which the unhealthy peach tree falls heir.

As preventive measures, several of more or less importance can be mentioned. As the fungus thrives best in a warm, moist and shaded location, anything that will overcome these conditions might be classed as a preventive. Too close planting is not recommended, as in such plantations a free circulation of air is shut off. Pruning to an open head would no doubt be an advantage in favor of the tree. In other words, plant and prune the orchard to favor a free circulation of air and plenty of sun about and on the inside of the tree. Experience with other mildews would seem to suggest that as a preventive measure, a cool soil and location be selected. Some have recommended the planting of varieties that seem to be free from attack, but in this state little or no preference has been shown by the fungus for certain varieties. The statement has been made that the disease seemed to be restricted to the serrate, glandless-leaved varieties, but in three lots of infested material sent in to the Station by fruit growers of the state two had serrate leaves and very conspicuous glands, while the third was serrate, glandless. It has been noticed that it is especially bad on seedlings in infested localities. It seems hardly necessary to take out infested trees as some have recommended, but no doubt the seedlings above mentioned could be disposed of at little loss to the grower and may noticably check the spread of the disease.

No extensive experimental work has been followed out along the lines of determining remedies for this disease; nevertheless, knowing its habit of growth and the action of the various sprays upon the peach, no fear is entertained in recommending a system

of spraying which will no doubt prove effective in holding peach mildew in check.

In his "Fruits of California" Wickson, on the subject of combating mildew says:

"This has been effectually done by thorough sulphuring. Mr. Klee advises three applications where mildew is apt to be bad; the first one very early in the season."

Owing to the smooth surface of the foliage of the peach such applications would necessarily have to be made early in the morning or after a rain, while the foliage is damp. Though the application is generally a very simple matter when the dust sprayer is at hand, it will not, as a rule, prove as satisfactory as other methods.

Lodeman, in his "Spraying of Plants," says:

"It is probable that the disease can be held in check by spraying the trees with Bordeaux Mixture as soon as the fruit has set, and follow this at intervals of two weeks by two treatments of one ounce of carbonate of copper dissolved in ammonia and diluted with twelve gallons of water."

Peach mildew being a surface grower there is no reason why any of our standard fungicides might not be employed in fighting it. A thorough spraying, before the trees come into bloom, with formula A or C, is recommended. After the blossoms have fallen, an application of B or D should be made. Follow this at intervals of ten days or two weeks with one or two more applications of B or D. While A and E are sometimes recommended for use on the peach while the tree is in full leaf they are liable to burn the foliage more or less, and though it may not prove dangerous to the life or health of the tree, it is well to give up their use for others that are safe as well as efficient. Formula B is a modification of the regular Bordeaux mixture sometimes recommended for the peach, and can be safely used upon the peach during the growing period. Formula E is a very safe and effective spray for the first application before the leaves come out, but others given are much more simple in preparation and just as effective.

FORMULA A.—Bordeaux Mixture.
Copper sulphate (Blue stone or Blue vitriol), 4 lbs.
Quick lime .... 4 lbs.
Water .... 45 gal.

FORMULA B.—Copper sulphate .... 2 lbs.
Quick lime .... 4 lbs.
Water .... 45 gal.

FORMULA C.—Copper sulphate .... 1 lbs.
Water .... 25 gal.

FORMULA D.—Copper sulphate .... 1 lb.
Water .... 400 gal.

FORMULA E.—Copper carbonate .... 1 oz.
Ammonia (enough to disolve copper carbonate.)
Water .... 12 gal.

The effectiveness of any of these sprays depends upon the

thoroughness with which it is applied, and pains should be taken to reach all parts of the tree. A nozzle that breaks up the spray well will save much time. Fresh unslacked lime only should be used. It should be slacked in water in a separate vessel diluted to a thin whitewash and strained through one or two thicknesses of burlap or sacking, or through a strainer with openings the size of a pin head, before using. This prevents the clogging of the nozzles with any of the coarse material left after slacking. The copper sulphate should be dissolved in warm water if wanted for immediate use. It may be dissolved in a considerable quantity of cold water by suspending it in a sack just beneath the surface. If to be used in large quantities it is well to make up a stock solution by dissolving fifty pounds in twenty-five gallons of water. Keep well covered to prevent evaporation. Two gallons of this solution contains the four pounds of copper sulphate called for in formula A, or one gallon contains the two pounds called for in formula B. The required amount of this solution should be diluted to at least thirty gallons before the lime water is added. The lime may be slacked in large quantities, in which condition it will keep well all summer, and the amount of lime water or paste required may be determined by a chemical test.

For this test potassium ferro-cyanide may be secured of any druggist and prepared for use by dissolving in ten times its bulk of water. A quantity of lime water is then added to the diluted copper solution, stirred well and a drop of cyanide dropped upon the surface. If it gives a reddish brown color to the mixture, more lime must be added and the test repeated until no reaction occurs. This indicates that all harmless acids of the copper have been neutralized and the mixture is ready for use. Red litmus paper may be used and lime added until the solution turns the paper to a blue color.

Bordeaux mixture deteriorates rapidly and should be used as soon as prepared. While being sprayed it requires constant stirring. In the preparation of the mixture no metal vessels or tool other than copper or brass should be used.

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The Agricultural Experiment Station
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Development of the Rockyford Cantaloupe Industry.

PHILO K. BLINN.

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Development of the Rockyford Cantaloupe Industry.

PHILO K. BLINN.

EARLY HISTORY.

Rockyford Netted Gem Cantaloupes have been produced in the vicinity of Rockyford for about twenty years, while other varieties of cantaloupes or muskmelons are reported as having been grown at an earlier period by the first settlers along the valley.

The honor of growing the first Rockyford cantaloupes for market is accredited to Mr. J. W. Eastwood now a resident of Phoenix, Ariz. The same season Mr. J. E. Gauger, a few miles west of La Junta also grew a small patch of the Netted Gems from seed secured from Mr. W. Atlee Burpee who introduced the variety in 1881.

Mr. Eastwood relates the beginning of the industry in the following narrative:

I removed from Denver to Rockyford in November, 1884, and as I had previously been growing the Netted Gem cantaloupes, I determined to try them there. Accordingly the following spring, I planted about one-half acre, and so far as I know, this was the first of this variety grown at Rockyford. Mr. G. W. Swink was growing a larger variety, but after making several close inspections of the Netted Gems as he saw them growing during the season, said he was convinced that they were the cantaloupes to grow.

He selected a dozen or so for seed which were the first of this variety in Rockyford to be saved for seed. I secured my seed either through Mr. Henry Lee of Denver or Mr. Burpee of Philadelphia.

At that time no thought was given to the improvement of the parent stock, from which such marked results have since been attained.

I do not now remember the amount of cash received from the product of this half acre. I shipped the melons mostly to Mr. Woodruff, a commission merchant of Leadville, who sold them for 10 cents per pound. which would be equal to about $6.50 per crate.

As the patch yielded well and the melons sold so readily, I wished before the season closed that I had planted several half acres, but during the seven years in which I grew cantaloupes at Rockyford, I rarely exceeded five acres each year. After the first two or three years a number of other farmers began growing cantaloupes.

In those early years the market was not crowded and by culling closely a good sale was realized for what was shipped. The cantaloupes were gathered in sacks and packed and shipped in barrels and boxes, and as the market was then principally in Colorado towns, the "empties" were returned to the growers. We had not thought of shipping in car lots, although watermelons were already being shipped in that way; sometimes straw was placed on top of the water melons and cantaloupes were added to the car.

We had no thought of co-operative organization as yet, but each suc-

ceeding year, new growers were added, and as the markets began to be more fully supplied with cantaloupes, they were sometimes over crowded at the height of the season; one year while I was there, the growers met and apportioned the markets, each grower agreeing to ship only to his own, during the rush of the season, thus equalizing the supply to the various markets.

At the commencement of the cantaloupe industry, a comparatively small area was under cultivation. Such farms as were found along the Arkansas were principally stock ranches, producing hay, grain and alfalfa seed. The gross returns from any of these crops were comparatively small, and the valuation of land was consequently low. In the vicinity of Rockyford, even as late as 1897, choice lands under ditches with the best water rights were purchased for fifty dollars per acre. Hon. G. W. Swink and other early settlers who were interested in the development of the valley, were enterprising in their efforts. In 1889 Mr. Swink attended a Beet Sugar Convention held at Grand Island, Neb., with a view of interesting the Oxnard's in the Arkansas Valley as a suitable location for a Beet Sugar factory. He became convinced that the farms in the Arkansas Valley were too large and the population too small to offer any inducement to the sugar beet industry at that time. He had the hope, however, that the cantaloupe industry, which had already brought encouraging returns, would provide a larger population and smaller farms, and thus bring about the conditions necessary for the beet industry. Accordingly on his return to Rockyford he set to work to encourage every available settler. His lands near Rockyford were divided into five and ten acre tracts; and opportunities to secure homes were freely offered to health seekers without means, good intention being the principle requirement. The lucrative promise of the cantaloupe industry, as well as the light character of the work, appealed to an intelligent class of people who found the climatic conditions of the East too severe.

The public spirit which was early manifested, as well as the enterprising character of the community, were potent factors in the development of the cantaloupe industry and led to the intensive farming which has since characterized the vicinity of Rockyford.

During ten or twelve years, small farms devoted to cantaloupe culture were constantly increasing. Some growers, fortunate in getting early melons and in shipping to reliable commission merchants, received gratifying returns; others from various causes received but poor returns and bewailed their fate in ever coming to the valley.

During the latter part of the first decade, it became evident that the production of cantaloupes had reached the limit of the

market then developed. One of the first evidences of "too many" cantaloupes, was the lack of boxes and barrels for shipping. Necessity, however, became the mother of invention, and someone conceived the idea of making a crude crate. Twelve-inch board and common lath were utilized, half of the length of the lath being used for slats, and as this happened to accomodate about 45 averaged sized melons, the size of the future standard crate was thus arbitrarily determined. Although the empty boxes were constantly being returned from the Pueblo and Denver markets, the local supply of lath and twelve-inch boards was soon exhausted.

Glowing reports from the first shipments of the season created such enthusiasm, that every melon which could possibly be shipped was hurried onto the market, only to find at the end of the season, that much of the crop had not paid express charges. The high prices which a favored few obtained at the beginning of the season acted like a lucky strike in a mining camp, and each spring found new growers and a constantly increasing acreage.

For many years the cantaloupes were shipped entirely by local express, each grower making his individual consignments to the various Colorado markets. In 1894 the first step toward co-operative effort in marketing cantaloupes was taken, groups of neighbors combining to load a ventilator car and ship by freight, thus securing greatly reduced transportation. The cars were consigned to commission men on the various markets who remitted to the individual consignors who made up the car. Messrs. G. W. Swink, A. C. Comer, A. P. Kouns were representative men in these early shipping groups. Two years later the growers, for the first time, were supplied with regular crates manufactured at the lumber mills. These were of the same dimensions as the first crude crate, and were essentially the same as those that have since been used.

Following the introduction of the crate, came the next step towards co-operative organization, when one of the shipping groups, already referred to, added a few members, elected officers, and effected a formal organization which has since been known as the "Kouns Party." Their plan was to ship to specially authorized agents or commission men who contracted to handle their cantaloupes exclusively. They shipped most of their cantaloupes to Denver, receiving fair returns considering the glutted condition of the Colorado markets that season. Their organization had its advantages, but as they had no control over the heavy shipments of others, the general results of 1896 were a repetition of former failures. Many growers after laboring all summer to produce a crop of cantaloupes, were presented with bills for transportation, their summer's labor having been sacrified as they believed, to the

railroad and commission men. A few cars of cantaloupes which Messrs. G. W. Swink and A. C. Comer that season shipped to Kansas City and St. Louis caused a new star of hope to rise in the Eastern horizon, and visions of great possibilities for future market developments.

The unremunerative returns of several years having created a strong public sentiment that something must be done, the time seemed to be ripe for a more comprehensive co-operative organization. Accordingly a meeting was called in the fall of 1896; by-laws were drafted and articles of incorporation were filed for the Rockyford Melon Growers Association. It embraced practically all the cantaloupe growers of Otero county with the exception of several individuals who by reason of the organization were able to secure good prices from certain commission men who were trying hard to disrupt the organization. The Kouns Party was absorbed by the Association, it being understood that H. Woods should represent the Association in the Denver market. The general plan of the Association was to market all cantaloupes possible, and when from lack of cars or insufficient market, the melons could not be handled, the grower was given a receipt and his cantaloupes returned to him to be cut for seed or to be fed to stock. The proceeds of those which were marketed were divided pro rata according to the receipts which the growers held.

The first season a contract was made with the Western Poultry and Game Co. of St. Louis, Mo., which agreed to take thirty-five cars during the season of 1897 at 75 cents per crate, f. o. b. at Rockyford. The quality of the cantaloupes that season was exceptionally fine, and they sold so readily on the Eastern markets, that by the close of the season the St. Louis firm had handled 121 cars. On several occasions, circumstances necessitated the return of the cantaloupes to the grower, which, according to the terms of the Association were receipted for, and which reduced the average price per crate during the season, yet for once in the history of the cantaloupe industry, the returns were satisfactory.

The following year the Manager of the Western Poultry and Game Co. came before the Association and reported that the previous year had been a profitable one to his company, they having cleared a considerable sum, exclusive of large amounts spent in advertising; he claimed that they had secured reliable agents in New York, Pittsburg and other cities in the East, to assist them, and offered to contract the crop of 1898 at 97½ cents per crate, f. o. b. at Rockyford. The proposition was received with enthusiasm.

The membership of the Association swelled to over 800 members, and the acreage increased to more than 5,000 acres in Otero

County. With the exception of a small body of men in Prowers County and two or three men in Otero County it comprised all the cantaloupe growers in the Arkansas Valley. Never before was there a closer organization of growers, or one in which members were more persistent in their determination to remain loyal to the organization.

Some attempts were made to influence growers to break the contract and leave the organization, some men even having their agents meet the growers on the road to the station, and offer an advance over what they expected to receive through the Association, but as there was a general feeling that they had been victimized by such men there is no record of any grower betraying the Association.

The harvest began early in August, a few crates at first which rapidly increased until 14 cars were loaded in a day. This jumped suddenly to 28 cars a day during the last week in August. Soon 150 cars were rolling to the Eastern markets when it was realized that the market would be glutted before the week's heavy shipment could arrive. Telegrams flashed the information and a halt was called, while the commission men hurried West to explain the situation. A largely attended mass meeting of growers met at the Fair Grounds in Rockyford to hear the report of market conditions. By telegrams, letters and able addresses, they were convinced that their cantaloupes were not so marketable as in the previous year. Over one hundred cars had been dumped in New York City alone and transportation charges of many thousands of dollars remained unpaid, which it was claimed they were responsible for because the melons were not merchantable.

The A. T. & S. F. R. R. offered to cancel the transportation due them from the lost cantaloupes. The commission firm offered to pay $18,000 of the $48,000 then due the Association, providing the latter would waive the balance and accept 75 cents per crate for the balance of the season. This proposition was accepted by the growers though it afterwards proved that the firm was unable to meet their promises and representatives of the Association were sent East to investigate the disaster. They reported and experience has since shown that poor refrigeration was the chief cause of the loss of the cantaloupes, the truth of the matter being that the industry had out grown the then poorly developed market facilities. Experience in handling the crop had not kept pace with the increased production.

As a whole the season's results were highly unsatisfactory. Seemingly the Association idea had received a death blow, yet the co-operation idea of the Association was not abandoned, it simply changed form. The various shipping points of La Junta,

Fowler and Manzanola withdrew and organized Associations of their own, then a Federation was perfected including these several Associations which provided a general marketing committee with representatives from each Association who were empowered to make the contracts with the commission men, thus uniform contracts were secured for the Valley.

By this time, the cantaloupe industry had been the cause of a large increase in population and the large farms had been broken up into smaller tracts. Then, too, in 1899 a large number of field tests of sugar beets by farmers demonstrated the possibilities in the Valley, and the following year saw the construction of a factory at Rockyford, thus realizing the early hopes of the original promoters of the Valley.

Many growers turned their attention to the new crop so that the tension of the cantaloupe situation was somewhat relieved, and cantaloupe growing has since become more profitable, the average price realized having gradually increased. It is true there have been seasons of high and low prices, influenced by various conditions which effect the marketing of any crop, such as over-production, quality, the abundance of substitute fruit, etc.

At Rockyford the original Association, with amended by-laws, was continued and is still a well organized body of growers. The growers who had been previously identified as the "Kouns Party," withdrew with others and reorganized, forming the "Kouns Party" of today. Their plan has been to ship exclusively on commission, each car being treated as an entirety and the returns prorated among the growers who shipped in the car. The plan has been popular with many growers and a number of Associations in the Valley have adopted it, shipping through the same commission firm—H. Woods of Chicago.

The Rockyford Association and those federated with it, since the disaster of 1898 have also resorted to the commission basis in general, shipping through the joint firms of Lyons and Coggins, the main difference being that in the Rockyford Association, the returns have been prorated, at first in daily pools and later in the season in weekly pools, instead of by the car as in the Kouns Party. The latter method although affording a quick account of sales, make the returns for each grower more subject to chance, since the particular car in which he ships may or may not encounter favorable conditions. Thus in this plan there may be a variation in the returns which different growers may receive who have shipped the same day but in different cars.

It might be well to state that up to the present time, there has been no classification as to quality there being but one grade of inspection. In the other plan, the returns for the day or week

being pooled, growers shipping at the same period will receive the same returns regardless of the conditions which their individual melons may encounter. Each plan has its advocates and on the whole both have given satisfactory results.

Since the division of the big Association of 1898, most of the cantaloupes have been marketed through the organizations and commission men above mentioned, yet from time to time, other commission men have made efforts to gain a foot-hold with the growers. Taking advantage of low market conditions, they would report high returns and in this way a number of growers have been drawn from the Associations. One after another of these firms has come and gone, each time leaving a sadder but more experienced set of growers.

The presence of these contending elements has in many cases hampered the results of the associations, causing unstable conditions. Thus, when the management insisted on the rules of the Association and the rigid inspection of cantaloupes necessary to the welfare of the industry, some over sensitive grower would "pull out" to the opposition who were ready and willing to receive his cantaloupes regardless of condition. A number of instances have occurred when loads of green or otherwise unmarketable cantaloupes have been refused at the Association platform, only to be immediately driven over to the car of some contending commission firm, where a large sum would be paid for the first load with promise of still greater returns subsequently if sent on commission. The result of trusting these promises, has shown them to be but a bait. Again the constant canvassing by these commission agents has tended to increase the acreage of cantaloupes, although experience has shown the industry to be overdone nearly every year.

Not only this, but the strife and competition have led to the shipping of green unmarketable melons in order to get the advertising which comes from shipping the first basket or crate of Rockyfords. Thus, in 1894, one of the new commission firms paid $10 for a crate of green cantaloupes which were shipped a week before the first really ripe cantaloupes were ready to market.

This shipping of green stock stimulated the practice in all of the Associations among impatient or inexperienced growers and resulted injuriously to the reputation of the Rockyford cantaloupes and has been an outrage upon the people who bought the fruit. A cantaloupe which is not at a certain stage of ripeness when picked will never be fit to eat, but the inexperienced commission man reasons that because fruit such as lemons, bananas and tomatoes can be marketed quite green and still attain perfection, that the same can be done with cantaloupes. This is a fatal mistake—as well

try to market green peaches, strawberries or watermelons, which only shrivel down and are worthless.

Many lessons beside those mentioned have been learned in the last six or eight years, and they nearly all attest the merits of well organized co-operative efforts to secure results.

During the coming season of 1906, the organized Associations will doubtless market most of the cantaloupes from the Rockyford district, although the firm of Young & Mathis of New York, who are large growers themselves, and who ship for individuals to some extent, may be a possible exception.

The growers in general have realized to their sorrow that the old adage, "Competition is the life of trade," is a poor maxim when applied to the sale of cantaloupes on commission—the commission men fight and the growers pay the bill. This has become such a reality that it has produced a strong sentiment in the minds of many growers in favor of a cash proposition.

As a result in recent years a cash advance of varying amounts has been granted in many of the contracts with the commission men, but there are many conditions which can not be controlled, such as the acreage needed to supply the market demands; the preventing of outside growers from selling on commission and thus competing with the man who pays cash, all of which seem to preclude the possibility of getting a cash price which would equal that now realized through reliable commission.

If the element of competition on the market were eliminated by the complete co-operation of the growers, and if the acreage were not increased beyond that indicated by experience, the price of cantaloupes would doubtless become more uniform from year to year.

The added strength of the established Associations, caused by the return of many of the disaffected growers; the securing of a uniform strain of seed for the members of these Associations, and the improving of market facilities are all factors which seem to promise better days for the cantaloupe industry and the realization of the co-operative ideal where all the interests of the cantaloupe growers become mutual.

Having summarized the growth of the industry from the grower's standpoint, the history would seem to be incomplete without a review of the market developments as witnessed from the distributing man's point of view; for in order to make possible this great industry which returns to the grower several hundred thousands of dollars each year, joint efforts were required on the part of both growers and market men, and without this co-operative effort, the industry would still be in a chaotic condition.

Lyons Brothers Co. of New York and M. O. Coggins Co.

of Pittsburg which jointly have directly or indirectly handled the cantaloupes of the Rockyford Melon Growers' Association since the first car went to Eastern markets, and H. Woods of Chicago, who has marketed the cantaloupes of the Kouns Party since its organization, represent the principal distributing agents of cantaloupe growers' organizations in Colorado during the past ten years.

Each has kindly contributed an article embodying much useful information relative to the co-operative organizations and the marketing of cantaloupes.

Mr. M. O. Coggins of Pittsburg had prepared an article entitled, "The Cantaloupe—From a Luxury to a Necessity," which he read before the National League of Commission Merchants in Milwaukee, and this article with supplementary information was to have been contributed to this Bulletin, but before he had time to prepare it, his sudden death immediately following his return, occurred, and the information expected to have been obtained from him, is limited to the article referred to.

His unexpected death has caused a severe blow to the cantaloupe industry, for without doubt his influence, as much as that of any one man has made possible the present development of the industry. Being identified with it from the first, his experience and judgment are a loss which will be felt. It was through his personal influence that the first cars were shipped east of St. Louis. In 1897, after several interviews over the long distance telephone with Mr. Nat Wetzel of St. Louis, he induced him, by a guarantee of $2 per crate, to forward a car of Rockyford cantaloupes, although it was doubtful whether cantaloupes could be carried farther east than St. Louis. Mr. Coggins lost 20 cents per crate but made good his guarantee, and the merits of the melons becoming known, he was able to realize a profit on subsequent shipments, and that season handled 8 cars of the first 30 received in St. Louis by the Western Poultry and Game Co.

THE CANTALOUPE, FROM A LUXURY TO A NECESSITY

M. O. COGGINS.

In the year 1870, it was an unusual thing to see a muskmelon on the market, but long in the eighties, they began planting in the Maryland Peninsula a variety known as the Anna Rundels and also some Jenny Linds.

These were placed on the market about the 10th of July, but shipments amounted to very little until about the 20th of July, continuing until the middle of August; these shipments gradually increased in quantity each year until the nineties, although the total receipts on the New York market would not amount to three cars a day at the height of the season and the prices ranged from $2.50 to $6.50 per basket.

Only a few of the fruit and vegetable men handled muskmelons and they supplied the hotels and restaurants. The high prices and limited supply made the cantaloupe a great luxury, too expensive for the average grocer to handle.

Beginning with the early nineties, there was a gradual increase in quantity as other sections of the country began shipping so that the season gradually began earlier until melons for the 4th of July market were no longer considered a novelty.

After the year 1897, when Rockyfords were placed on the different markets and the standard crate established, the Rockyford seed for planting came to be in great demand in the southern states.

In 1898, the first cars of southern cantaloupes grown from Rockyford seed were shipped from Hitchcock, Texas, and in the following year the first carloads from Florida arrived in New York on June 2; these were followed by shipments from Georgia, the Carolinas and other points farther north, keeping a steady supply on the market until the last shipments of the Colorado melons.

The effect of the use of the Rockyford seed and of the standard crate was to make the cantaloupe a standard article of trade so that regular quotations could be made.

Orders were received from cities and towns tributary to the large receiving points, causing a demand at small points as well as large ones. This demand has increased so enormously since 1897, that I thought possibly a few figures carefully estimated would be of interest.

In 1897 the amount consumed througout the United States was not over 400 carloads, gradually increasing until during the past season of 1905, 6,920 carloads were used throughout the United States. The three largest markets the past year handled 1,460; 715 and 660 cars respectively. While the season for cantaloupes has changed from a period of less than two months to six months of carload business.

The past three seasons have opened up about May 12 with shipments from Florida, car lots having been received on the market as early as May 22. During the height of the season, New York alone has received as high as 35 cars in a day.

Prior to the introduction of the Rockyfords, the markets had no uniform style of package, shipments being received in baskets, barrels, strawberry crates and sometimes in dry goods boxes. There being no uniformity, quotations were impossible, but with the establishment of the standard crate containing a uniform number of cantaloupes, the cantaloupe became a standard article of fruit which can be quoted intelligently, the buyer knowing what he is to receive in size and number, since the Rockyford seed produces the same size and shape in all states and is the only shape of cantaloupes that the buyers will buy. This has made it possible for both individuals and companies to plant a very large acreage.

To give some idea of the seed industry, there was saved in the past season in the Rockyford district, from 90,000 to 100,000 pounds for distribution in the different melon growing sections of the country.

Before the advent of the Rockyfords, a ten-acre patch was considered a large venture for any one grower and it is now well known that in some states one grower may sometimes attempt as high as 150 acres.

Prior to the Rockyfords no muskmelons worth speaking of were raised south of the Maryland Peninsula in the East, and Indiana and Missouri in the West; at the present time there are grown in the state of Florida, about 4,000 acres; in Georgia, about 4,000 acres; in North and South Carolina, about 4,500 acres, to say nothing of the aggregate of small acreage in other states; the total for the United States during the past season being not less than 58,600 acres.

The supply from the beginning is continuous, the season in one state over-lapping that in another so there is no time after the commencement of the melon season when the markets are not supplied. Thus the trade has an opportunity to handle and the consumer an opportunity to purchase, so the cantaloupe at the breakfast table is no longer considered a luxury but a necessity.

EARLY MARKET CONDITIONS OF CANTALOUPES ON THE NEW YORK MARKET.

LYON BROTHERS COMPANY.

Prior to 1897, the eastern markets were supplied with Anna Rundels, Jennie Linds and the Hackensack variety of muskmeolon; these came to the New York market in packages of every description, there being no uniformity of package or any effort to establish one.

The melons were irregular in size, variety and quality; the flesh was generally thin, the seed cavity large, the flavor irregular.

The bulk of the receipts for the New York market came from Maryland, Delaware and New Jersey. Evidently there was no systematic organization of the growers as the shipments were spasmodic; at times the market was glutted, at other times deficient, and the irregular conditions which prevailed made it impossible to give a standard market quotation.

The melons were sold by men whose principle business was the selling of vegetables and the prices realized were according to their ideas rather than from any regular market quotation, which today gives the grower accurate information of the condition of the market.

HOW ROCKYFORDS CHANGED CONDITIONS.

In August, 1897, Rockyford cantaloupes, packed uniformly in crates containing 45 cantaloupes, were received on the New York market; the thick flesh, small seed cavity and delicious flavor, made a sensational reputation for the Rockyford cantaloupe as being the very finest ever placed on the New York market. These melons we received from the Rockyford Melon Growers' Association, and the form of crate which originated there, was soon adopted as the standard package for market quotations, and soon came into use throughout the melon growing sections of the United States.

The ready sale of the Rockyfords, the organization of the growers which insured the uniform crates, and the fact that the melons were grown under irrigation and about the same quality could be produced every year, were facts which convinced us that the Rockyford would become as standard an article of trade as a barrel of apples.

Accordingly, we determined to make cantaloupes one of our specialties, and for several years were the only house in New York handling the product. By thorough advertising the Rockyford cantaloupe became famous in all the Eastern states.

The introduction of the Rockyford cantaloupe prolonged the market season in New York City from about September 5 to the middle of October.

Experiments showing that the Rockyford seed would reproduce its superior qualities when grown in the South or East, led to extensive planting in the Southern states—700 acres being planted in these states in 1899. The melons from these states came on early in May, thus opening the market two months in advance of previous years. In 1905, the first crate was received from Florida on May 12, and the supply continued from the various states in succession until October 23, making a period of nearly six months.

The fact that the cantaloupe seed produced in Colorado under irrigation, will produce earlier melons and of a superior quality, than the same strain when grown in other states, has been verified each year, and thousands of pounds are annually sent to the Southern states and California from Colorado.

Owing to the development of this phase of the industry, it behooves the Colorado grower to use the utmost care in the selection and development of his seed, in order to maintain the trade of the United States which looks to him to supply a superior grade of seed.

Every communitty of growers should organize an association which would make rules enforcing the planting of a strain of cantaloupe seed

known to have the best line of selection. They should insist on uniform grading and packing and permit no inferior cantaloupes to be marketed or even cut for seed.

By such action a reputation can be secured and maintained which will greatly benefit the melon industry. On the other hand, carlessness on the part of a few, may work irreparable injury to the industry.

We wish to express our satisfaction in dealing with organized growers. It has been more satisfactory to the growers themselves as well as the trade, and the co-oprative spirit that has been shown in some of the communities of the melon growing section in Colorado, is worthy of being emulated in other sections of the country.

Transportation under modern refrigeration has made possible the great melon industry. Melons will carry to the most distant markets if the proper conditions are provided. Usually the melons are warm when loaded, the temperature often being over a hundrd degrees in the shade.

The car may stand six or eight hours before it is made up and even if it starts soon after being loaded, the enormous heat in 350-400 crates of melons is more than the ice in the bunkers can absorb; the hot, close air generates a ferment that results in the partial or complete loss of the melons. It is a fact that in cars of cantaloupes which heat or are spoiled, the injury is done in the first 24 hours.

Mr. L. M. Lyons, the President of our Company, has been studying the problem and has perfected a patent cooling process, which exhausts the hot air while the car is being loaded and waiting to start on its long journey, thus avoiding the formation of degenerating gases.

During the season of 1905, the process was used for the first time at Thermal, Cal.; the cars were three days in being loaded and the outside temperature during the day varied from 123-130 degrees in the shade, but arrived in New York in perfect condition and sold as high as $2,506 gross, per car.

During the coming season, the process will be tested in Colorado and the Southern states.

MARKET DEVELOPMENT OF THE ROCKYFORD CANTALOUPE.

H. WOODS.

My experience with the Rockyford cantaloupe began in Denver, fifteen years ago when one wagon could have delivered the daily consignments and my yearly sales did not exceed $500. Since that time I have witnessed the growth of the industry and its market developments until the present time when my cantaloupe business amounted to $250,000 for the season of 1905.

A story of the early market conditions of the Rockyford cantaloupe would be a varied one, telling of irregular cantaloupes, in irregular packages, coming in irregular consignments to irregular commission men, who remitted irregular returns to irregular growers.

From the beginning of my experience in Denver, the market, at some period in nearly every season would be over-crowded with melons.

The melon is at best a very perishable article and may be in perfect condition today, but soft and undesirable tomorrow. When the market is over-supplied each subsequent consignment makes more difficult the sale of stock already on hand, consequently the price drops, and transportation charges may not be realized. This has been the cause of many of the discouraging remittances to growers.

The recollection of some of the critical experiences of the early melon market in Denver is far from pleasant. Often the commission houses were overstocked and yet in spite of repeated advices by mail and wire, the growers would continue their consignments, although there was little hope of even securing transportation charges.

The adoption of the standard crate and the co-operative idea of some of the growers, made possible the wider development of the cantaloupe market throughout the United States.

The subsequent organization of the growers to provide a satisfactory market for their cantaloupes was a wise step.

The season of 1898 was a disastrous one. The elements leading to this failure being, poor quality, a partial failure in refrigeration, over-production, and the fact that a large proportion of the men handling the cantaloupes in the East, had but little experience or knowledge of the product, and the proper method of handling on the market.

Believing my experience with the Rockyford cantaloupe in Colorado would be useful to myself and the industry, and the industry having now become national rather than local, in 1899, I contracted to handle on a commission basis the cantaloupes of the Kouns Party on the Eastern market.

I went to New York to thoroughly study the conditions in the East, and to discover what improvements could be made in the distribution and handling of the cantaloupes on the Eastern market, also the necessities for their proper transportation and refrigeration.

From my experience and observation that year, I decided that Chicago was the best point from which to distribute the product.

Chicago was not only one of the largest cities in the country, but it was on the only line of railroad running through the cantaloupe belt of Colorado, although as yet Chicago consumed but very few Rockyford cantaloupes.

Accordingly in 1900 I located in Chicago continuing my contract with the Kouns Party and other Associations in the Rockyford country.

My long experience in the business, enabled me to secure good responsible parties in all the leading cities of the country to handle these cantaloupes for me. In the Chicago office, I was in daily touch by wire with all these agents, also, with the conditions of the cars in transit. These were inspected at the Missouri River and again at Chicago and forwarded to the different markets according to their condition, only the firmest and best stock being allowed to continue on the long journey to the seaboard.

It has taken since 1899 to build up this system and secure agents who can always be relied on to give attention to the business at the proper time.

The average price paid to the grower gradually increased from 1899 to 1903, averaging about a dollar per crate for the period of five years. The increase in price had two results which led to the almost complete failure of 1904: 1st the profits to the grower during the period of prosperity led to more extensive planting, resulting in over-production; 2d, the profits to the distributors during the same period, led new men without a comprehensive knowledge to go into the field and contract as distributors; this increased competition, led to the placing of many inferior melons which otherwise would not have been shipped, thus further overcrowding the markets and lowering the price below the point of profitable production, and in the case of some firms at an actual loss to the grower.

The poor results of 1904 materially decreased the acreage for 1905 and caused a much larger proportion of the melons to be handled by experienced distributors, so that the results to the grower were again satisfactory, reaching the highest average paid the grower in the history of the melon industry in Colorado.

To sum up the situation: The successful distributor must thoroughly know the source of supply; understand the handling of the melons from the field to the car, also the loading and cooling of cars, the proper refrigeration, the conditions and requirements of the different markets, and must have capable and experienced agents to handle the melons in the different cities of the country.

These, together with the support of an organization of growers,

who are loyal to their own best interests as represented by the objects of their association, will assure the prosperity of the industry.

TRANSPORTATION.

During the last nine years, 5,999 cars of cantaloupes were shipped out of the Rockyford district, being an average of 666 cars per annum. In 1904 the largest number were shipped, 1,182 cars, and in 1897 the smallest number, 121 cars.

The transportation feature of the cantaloupe industry is perhaps the most important of any. In the early stages of the cantaloupe industry the largest cars in use measured from 32-34 feet in length, outside measurement. Today the predominating car is 40 feet, outside measurement, which allows 32 feet 5 inches inside length; 8 feet 2 inches width and 7 feet 3 inches in height.

The crates are loaded lengthwise and space allowed between each tier for the circulation of the cold air. A 40 foot car permits 24,000 pounds or 366 standard crates of 66 pounds each, to be loaded in tiers not exceeding three crates in height, except a few tiers near the ice box. The warm air necessary rises to the top of the car, and if the cars are loaded more than three tiers high, the top tier generally arrives at its destination in a worthless condition.

It has been the experience of all receivers during the past years that it is not best to load cars to exceed 24,00 pounds, or 364 crates.

The system of icing the cars in vogue at present is to ice the empty cars at La Junta during the night and send them on a special train about 6 o'clock in the morning to the Rockyford district and stations west, or by the east-bound freight to stations in the Las Animas district.

The initial icing requires about 9,000 pounds. After loading, the cars are returned to La Junta and re-iced with about 6,000 pounds of ice.

The melon train arrives at La Junta from stations in the Rockyford district about 9 p. m. After re-icing the cars they depart for the East on trains leaving La Junta about midnight. In the height of the season, the train is a complete melon train.

During the very warm weather when the temperature ranges to 90 degrees and upwards, the rear vents are left open until Dodge City is reached. This is for the purpose of permitting the gases and hot air to escape from the car. Cars re-iced at Dodge City take an average of about 4,000 pounds of ice. The next icing station is Newton, Kan., where about 5,000 pounds more of ice are required. Argentine follows, with 4,500 pounds.

The run from La Junta to Argentine is 36 hours. At La Junta, Newton and Argentine, the S. F. R. D. Co. and St. F. R. R. each have ice inspectors whose duty is to see that the cars are

properly iced in accordance with instructions. These require that the ice shall not be in chunks larger than 50 pounds and that the bunkers shall be filled to full capacity at each icing station. There is no salt used but the ice is properly packed into the bunkers.

Argentine is a diversion point for most of the receivers and each has a representative to inspect the condition of the cantaloupes as well as the ice in the bunkers. On the report of the inspectors at Argentine is determined the diversion to long or short-haul points. The run from Argentine to Chicago is 30 hours.

Cars are re-iced at Corwith, the outer yard of the S. F. R. R. at Chicago, and usually require from 2,500-3,000 pounds of ice.

Full record of the movement of all cars is kept by the S. F. R. R. Co., being received by wire from La Junta, Dodge City, Newton and Argentine. Diversions may be accomplished at any point from the line of the S. F. R. R. on very short notice, by reason of this accurate record. Some through cars for the Eastern markets do not pass through Chicago but are given to the I. I. & I. R. R. or some other outer belt line which delivers to the Eastern connections without passing through Chicago, but on account of the advantage of inspecting cars at Corwith, it has been deemed advisible in late years to have all cars pass through Chicago. The melon train usually arrives at Corwith between 5 and 6 p. m., leaving ample time to re-ice cars and make Eastern connections.

The Bohn patent refrigerator car is used by the S. F. R. R. Co. giving more satisfactory refrigeration than the old style for the reason that the ice tanks are not covered but separated by a grating only, thus allowing the cold to permeate the car, and in this manner the car receives the full advantage of the ice.

In former years, cantaloupe cars were not iced prior to loading and then re-iced immediately after loading. The custom was to ice cars at La Junta, send them down to loading stations and not re-ice until cars reached Argentine. By that time the ice in the bunkers was practically exhausted, the melons ruined, and all the ice which could be put in the bnnkers could not restore the damage to the melons. The striking contrast of the present system of re-icing the cars immediately after loading and keeping the bunkers well filled to destination, uniformly brings the cars to destination in first class condition and claims for damages are reduced to the minimum.

The time consumed in transporting cars from Chicago to New York is about 60 hours, and from Chicago to Boston about 84 hours. When cantaloupes are in good condition when picked and are loaded properly, the cars well iced and transported without unnecessary delay, they should arrive even on the Atlantic seaboard, in practically as good condition as when shipped.

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The Agricultural Experiment Station

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Cultural Methods for Sugar Beets

PROGRESS BULLETIN

By W. H. OLIN

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CULTURAL METHODS FOR SUGAR BEETS

PROGRESS BULLETIN

By W. H. Olin

I. Sugar Beet Investigations Already Made at the Colorado Experiment Station.—Investigation work on sugar beets was begun by the Agricultural College before the organization of the Experiment Station. This was done under the direction of President C. L. Ingersoll who had great belief in the possibilities of sugar beets. The first bulletin on sugar beets issued by the Experiment Station was No. 7 in 1888. Since then it has published twelve bulletins on the subject of sugar beets. Most of these bulletins were prepared by the Chemical section of the Station and dealt quite largely with the chemical properties of beets and effect of soil conditions upon the crop.

Prof. W. W. Cooke (Professor of Agriculture) in 1898 began a study of cultural methods, seeking to determine the best time for planting, best distance between rows, proper distance for thinning in the row and how to handle the irrigating water to obtain the best crop. These experiments were reported in bulletin 15 and were strongly in favor of early planting. Definite conclusions were not obtained upon the other problems, which still await solution.

II. Cultural Methods of our Most Successful Sugar Beet Growers.—To learn the cultural methods practiced by our most successful sugar beet growers, question circulars were sent to 1000 beet growers well distributed in three beet regions of the State; Northern Colorado, Arkansas Valley and the Western Slope region. These growers were selected as representing the growers who were obtaining the best tonnage and therefore getting the most profitable crop returns. The circulars were sent out in June and October of the crop season 1905. They contained the following questions:

1. Number of acres you now have seeded in sugar beets?
2. Number of acres you had in sugar beets last year?
3. Date of seeding beets last year?
4. Date of seeding beets this year?
5. Amount of seed used per acre?
6. Do you tend your own beets?

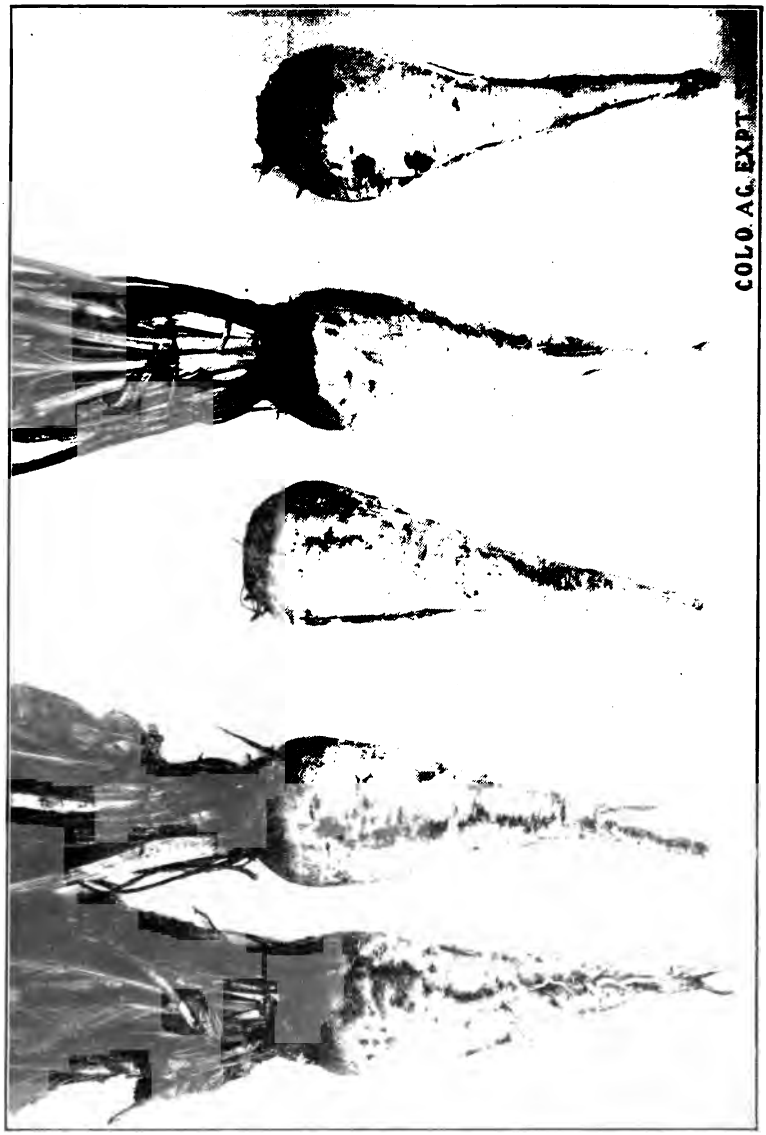

PLATE I.—DESIRABLE TYPES OF SUGAR BEETS
(TOPPED BEETS INDICATE METHOD OF TOPPING)

7. If you employ labor, which have been the most satisfactory—Italian, Mexican or Russian help?
8. Do you fall plow or spring plow for beets?
9. How do you prepare your seed bed for beets? (Please name the operations.)
10. What rotation do you practic for beets—that is, what crops do you grow after beets, before you again plant the same ground to beets?
11. How many times do you cultivate your beets?
12. How many times and when do you irrigate your beets?
13. Do beets require more or less water than other crops?
14. How many loads of manure per acre do you consider best for beets? What kind?
15. How many seasons do you think you can obtain a satisfactory yield of beets without manure?
16. What is your experience with barnyard manure for beets?
17. Do you advise the use of commercial fertilizer for beets? If so, what kind?
18. What is the character of your soil?
19. What do you consider the after feed (tops, etc.) left on the ground worth?
20. What tonnage per acre did you harvest last year?
21. What was your net profit per acre last year?
22. What is the average expense per acre for growing beets on your land?
23. How do beets compare financially with other crops?
24. Would you advise your neighbor to grow sugar beets as a profitable crop?
25. What trouble have you had with insects or plant diseases attacking your plants?
26. To what space between plants do you prefer to thin your beets? Will a greater distance increase or decrease the tonnage and size of beets?
27. Have you grown a satisfactory beet crop on alfalfa sod?
28. Do you think a grain or other crop should be grown on alfalfa sod before planting to beets?
29. What is the effect of early and late seeding upon the yield and quality of beets?
30. Does late summer irrigation tend to ripen the beets earlier or does it seem to prolong the period of ripening?
31. When did you pull your beets this season?
32. What was your 1905 yield?
33. What was your per cent. tare at factory?
34. Was this caused by shape of beet, manner in which the beets were harvested, or dirt on beets?
35. What was the condition of the ground when you pulled your beets?
36. Was the beet crop a satisfactory one in your neighborhood this season? What was the average tonnage per acre?
37. What suggestions in reference to sugar beet culture or problems which you believe essential will you give us?

It is to be regretted that many to whom this circular was sent neglected to send in reports. Less than 50 per cent. sent in a complete report from which we can quote. From the replies sent in to these question circulars, the following facts were gleaned:

1. Plowing of Beet Ground.—54 per cent. of those reporting, plow their beet ground in the spring; 26 per cent. plow their

PLATE II.—UNDESIRABLE TYPES OF SUGAR BEETS

beet ground in the fall; 20 per cent. irregular, part of the time spring plowing and occasionally disked potato ground.

TABLE No. 1.

PLOWING BEET GROUND AND RESULTING YIELDS

(IN TONS PER ACRE).

	Spring	Fall.	Indifferent
Arkansas Valley	18 1	19.2	18 2
Western Slope	18.0	16 6	16.0
Northern Colorado	16 7	14 5	17.2

Further data is necessary to show the value of fall plowing recommended for every section of the state growing sugar beets.

2. *Date of Seeding.*—Between first week in April and first week in June; 61 per cent. seed in the month of May.

TABLE No. 2.

TIME OF SEEDING AND AVERAGE YIELD PER ACRE

(IN TONS PER ACRE).

Localitv.	April.	May.	June.
Arkansas Valley	19.3	20.6	18 3
Western Slope	17.6	17.7	
Northern Colorado	15.7	18.4	*20.0

*Only one reported June planting, therefore it is not comparative.

The study of time of planting shows more clearly than this table reveals that usually early planting is best for yield and quality.

3. *Amount of Seed per Acre.*—The amount of seed used was from 12 to 25 lbs. per acre. The great majority reported using 15 to 20 lbs. per acre.

TABLE No. 3.

AMOUNT OF SEED PER ACRE AND AVERAGE YIELD

(IN TONS PER ACRE).

	12 lbs.	13 lbs.	14 lbs.	15 lbs.	16 lbs.	17 lbs.	18 lbs.	19 lbs.	20 lbs.	21 lbs	22 lbs.	23 lbs.	24 lbs.	25 lbs.
Ark. Valley				14		19.8	19.3		18 5					27.5
Western Slope	*22			19.6	16 0	17.0	19.0		18 0					
Northern Colo.	*20		18	15 5	17.0	17.1	19.2	14	18.5					
Average Yield	21		18	16 3	16.5	17 9	19 1	14	18 3					

*Only one reported 12 lbs. seed per acre. The majority reported the use of from 15 to 20 lbs. per acre.

4. *Help Preferred.*—46 per cent. of those reporting preferred Russian labor. No particular class of laborers received a satisfactory vote from the rest.

5. *Space Thinned in Rows.*—This varied from 6 to 16 inches the average being 10.4 inches.

TABLE No. 4.

SPACES THINNED IN ROWS AND AVERAGE YIELDS.

(IN TONS PER ACRE).

	8 to 10 in.	11 to 13 in.	14 to 16 in.
Arkansas Valley	18.	20.	23.
Western Slope	17.7	19.7	
Northern Colorado	15.7	18.4	20.
Average	17.1	19.3	21.5

The majority reported from 10 to 12 inches. Further work is necessary on this point. The table clearly shows the advantage in point of yield for the wider spaces in the row.

6. *Number of Cultivations.*—44 per cent. cultivate 4 to 5 times. 31 per cent. cultivate 6 to 7 times. 25 per cent. stated they cultivated two, three, eight, ten or as many times as the crop seemed to require cultivation.

TABLE No. 5.

NUMBER OF TIMES CULTIVATED AND AVERAGE YIELDS.

(IN TONS PER ACRE.)

	3	4	5	6	7	8	As often as needed
Arkansas, Valley	20.0		16.6	20.	22.2	17.	18.5
Western Slope	19.2		19.	17.			20.0
Northern Colorado	19.6	18.3	16.	18.	*13.5		17.0
Average	19.3	18.3	17.2	18.3	17.8	17.	18.5

* Only one reported

This table does not give us positive data and further work is necessary to draw conclusions.

7. *Times Irrigated.*—56 per cent. report two to three times.
18 per cent. report four times.
15 per cent. report often as needed.

From answers sent no definite data on yields could be obtained.

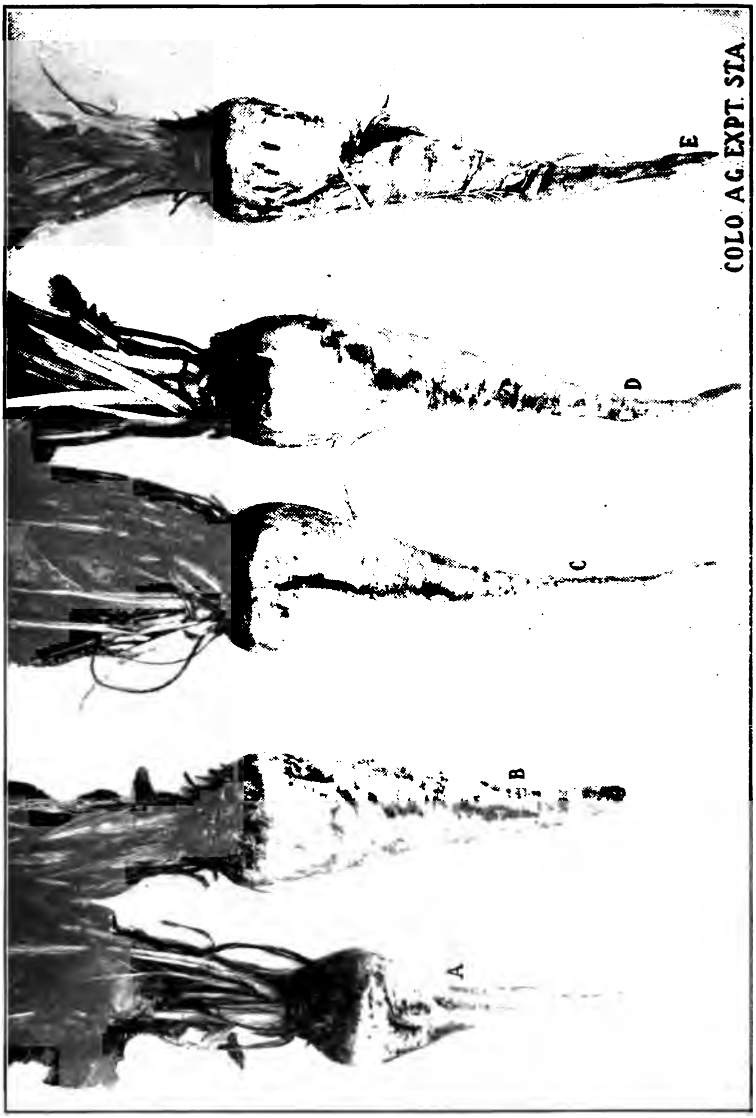

PLATE III.—VARYING TYPES OF SUGAR BEETS

A—Burned off by stable manure unevenly distributed in row. *B*—Spiral constrictions on beet. *C*—Rapidly tapering beet—a loss in tonnage. *D*—Irregular spiral depressions on beets. *E*—Irregular growth of fibrous roots.

8. To the question *Do Beet Crops Require More or Less Water than Other Field Crops.*

38 per cent. said more water.
30 per cent. said less water.
31 per cent. said same as other crops

9. Value o1 after Crop, Tops, Etc.—In answer to this question, 65 per cent. placed the value between $2 and $3 per acre, while the average value assigned was $3 per acre.

10. Tonnage for 1904. — The average for those reporting was 17.4 tons per acre. The state average for the same year was less than 12 tons.

11. Tonnage for 1095.— The average yield reported was 14¼ tons per acre, which is several tons above the estimated average of the State. This would indicate that 1904 was a more favorable year for beet culture than 1905, and that those reporting are among our most successful farmers in this industry.

12. Expense per Acre.—The expense differed according to locality from $20 to $50, but the average was $33.05 per acre.

TABLE No. 6.

COST OF PRODUCTION.

	Average yield per acre Tons	Average cost growing per acre.	Total income per acre.	Cost of growing *ton of beets.	Total profit per acre.
Arkansas Valley	19.9	$31.10	$96.60	$1.56	$65.50
Western Slope	17.7	34.80	85.20	1.96	50.40
Northern Colorado	17.1	36.43	84.68	2.13	48.25

* Minus the tare.

13. Net Profit of the Crop.—The reports varied to a remarkable degree, from nothing to $75.00 per acre. It was almost impossible to strike an average, the greater number reporting between $40.00 and $55.00 per acre.

14. To the question *Number of Years Beets Have Been Grown on the Same Ground Without a Change of Crop?*—The average was two years. However, most of these farmers have been growing beets but two years.

15. To the question *Do You Manure Your Beet Land?*—59 per cent. report they do, 41 per cent. report they do not.

TABLE No. 7.

BEETS GROWN WITH OR WITHOUT MANURE.

YIELD, TONS PER ACRE.

	With Manure	Without Manure
Arkansas Valley	19.5	14.2
Western Slope	17.5	13.4
Northern Colorado	16.8	15.3
Average	17.9	14.3

This table shows the value of manure for the beet grower. More farmers in the Arkansas Valley are using stable manure or fertilizers than either of the other sections of the state.

16. Time of Pulling Beets. — Time of pulling beets was reported from September to November, the great majority harvesting in October.

17. The per cent. of Tare. — This was reported from 1 per cent. to 23 per cent. The majority, however, was less than 5 per cent.

18. Cause of Tare—75 per cent. of the farmers reporting believed it was due to the dirt clinging to the beets when harvested. The rest attributed it to defective methods of harvesting and character of crown growth.

19. Condition of Ground at Harvest Time. — The great majority report the ground very dry and cloddy at pulling time. This is largely governed by climatic conditions beyond the beet farmer's control.

20. Is the Crop a Satisfactory One? — 80 per cent. of the reporting farmers declare it to be the most profitable crop which they can grow. The following statements are given by farmers having at least four years of successful experience in sugar beet culture:

1. The sugar beet crop is an expensive one to grow and should be grown on the very best land on the farm.

2. One should not bring to the surface more than two inches of new soil in plowing. Ground which has not been worked holds its plant food in a form not easily available to the plant. The young beet plant does not obtain proper nourishment from such soil and is checked in the beginning of its growth. When proper conditions prevail, beet ground should be plowed at least 10 to 12 inches deep. When beet land is plowed in the fall, the soil is weathered, rendering plant food at surface easily available to young plants.

3. Beet ground should be as uniformly level as the lay of the land will permit.

4. Early planted beets have generally given the best yields. The seed bed should be warm, *Moist*, but not wet, for the best germination.

5. A uniform stand is seldom obtained when seed is covered more than two inches deep. The vitality of the beet seed does not seem to be sufficient to send the sprout out of the ground from greater depths. Moisture conditions must indicate the depth to plant, as a shallow covered seed makes a rapid growth with proper soil and moisture conditions.

6. Early thinning of beets has given the best results, since young plants recover from the effects of the thinning process without too serious a delay in plant growth. The beet farmer aids in the thinning process by seeding not more than 5 to 10 acres at one time. His help can get over his entire field before the beets are too large for successful thinning.

7. Cultivation is for the purpose of keeping down weeds, prevent baking of the surface and give encouragement to continuous development of the beets.

8. The judicious use of water tends to produce well shaped beets, increases the tonnage and gives a good sugar content, when proper sun and soil conditions prevail.

9. Each factory furnishes field superintendents who are assisting farmers to learn the efficient use of water in sugar beet culture.

10. Beet farmers should plan for at least four weeks of the growing season after the last irrigation to mature the crop.

11. The Colorado climate,sun and soils are well adapted to sugar beet culture. This industry seems destined to grow with the development of irrigation in the state.

12. The growing of beets requires a crop rotation which shall maintain the humus and plant food elements in the soil. In Northern Colorado where sheep feeding is carried on quite extensively, the manure is carefully saved, composted for a year, and then hauled to the beet lands.

13. A practical rotation of alfalfa, potatoes or other cultivted crop, beets and grain is being gradually adopted.

14. The culture of sugar beets is improving farm methods in all crop production.

The Station has planned some cultural experiments with sugar beets and other root crops for the seasons of 1906, 1907 and 1908 for the purpose of determining the best methods for improving the quality and increasing the tonnage of these most profitable crops. Results will be given in other progress bulletins.

Bulletin 110 April, 1906

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

ALFALFA

(Results Obtained at the Colorado Experiment Station)

By

W. P. HEADDEN

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THE AGRICULTURAL EXPERIMENT STATION

FORT COLLINS, COLORADO

ALFALFA

(Results Obtained at the Colorado Experiment Station)

BY

W. P. HEADDEN

It has frequently been suggested to the writer that he should prepare a short bulletin on alfalfa, containing many of the facts presented in Bulletin No. 35, and such others as may have been acquired since its publication.

History.—This plant is known under the name of Medic, Lucern and Alfalfa. The latter is the name under which the Arabs introduced it into Spain, whence it was brought to the Americas. The plant with its Arabic name was introduced into California in the early fifties by the Chilians, and thence into Colorado.

The plant has been known since 490 B. C. at least, for in that year it was introduced into Greece under the name of Medic, signifying that it came from Media.

Culture.—The methods of culture are quite uniform in all sections where the plant is grown, and all the data collected on this subject show that the methods now followed have been practiced in all essential features for centuries. The principal points are a well prepared seed bed, good, plump seed planted deep enough to assure germination, which varies with the climate and soil from very shallow to three inches deep. The common practice is to drill in the seed with a protective crop, oats or spring wheat.

I have not yet seen or learned of alfalfa having been grown in drills and cultivated, except on a small scale, though there are records of such a practice and the results were excellent. The plants were set six inches apart, with two feet between the rows, and when cultivated and manured did not deteriorate at any age. The latter claim may well be doubted, but observations made on plants growing singly either without any, or with a pseudo-cultivation, and on plants grown in single drills with cultivation, strongly corroborate the claims made for the practice.

Varieties.—The varieties of alfalfa experimented with, three French varieties, the Turkestan and the common home grown seed, have not shown material differences in composition. Whatever differences may have originally existed between the French varieties practically disappeared under our conditions of soil and climate. This was not the case with the Turkestan which was very uniform and distinct in habit.

There are few plants which show greater individual differences than alfalfa grown from our home grown seed, and it would seem very probable that we could develop a variety superior even to the Turkestan by a little patience and judicious selection. Our common alfalfa presents two types, readily recognized by the growers; one has a dark green color and narrow leaves with red stems and usually deep violet purple flowers, while the other has green stems and much lighter flowers. The former is leafier and earlier than the latter, but is possibly a little less vigorous grower. In the color of its leaves and habit of plant, the former resembles the Turkestan.

Range of Soil and Altitude.—Alfalfa thrives in all of our Colorado soils which are not too wet. In some sections it is short lived due to winter killing, but I have seen fine alfalfa, on good soil with a favorable aspect, at an altitude of nearly 9,000 feet. The altitude at which it will do well varies with location and other conditions.

Amount of Water Required.—Like other questions pertaining to a general practice the answer is difficult to give, but it is safe to assume that it will require from twenty to twenty-four inches of water to the acre to grow the three crops usually cut in this State.

The Time of Cutting.—The first cutting is usually made between early bloom and half bloom. It is not so common to let it stand till the plant is in full bloom as it was at one time. If the weather is favorable the first cutting is made as early as possible to give a longer season for the growing of the second and third cuttings. Some regard is also had for the purposes for which the hay is to be used. I believe that the best hay for feeding purposes is obtained by cutting when the plant is in full bloom, but it is the general practice to cut it in early bloom.

Composition of Hay Influenced by Condition of Plant at Time of Cutting.—The chemical composition of the hay produced is not so materially affected by the condition of the plant at the time of cutting as we are wont to think. With us the weather exerts a big influence on the rate of growth and early blooming of the plants, this is most marked in the second cutting in which the condition of half bloom, for instance, may correspond to an earlier period of growth in the first cutting, so far as composition is concerned.

The following analyses taken from Bulletin 39 of this Station, give, I believe, a fair example of the range in the composition of alfalfa hay as affected by the time of cutting.

Cutting	Condition of the Plants	Air Dried Hay. Moisture	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen-Free Ext.	Total Nitrogen	Thoroughly Dried Hay Ash	Ether Extract	Crude Protein	Crude Fibre	Nitrogen Free Ext.	Total Nitrogen
1	Coming in bloom.......	7.22	9.81	1.15	15.16	36.49	30.17	2.426	10.57	1.24	16.47	39.48	32.29	2.624
1	In half bloom...........	7.92	11.89	1.26	14.46	32.80	31.67	2.310	12.92	1.36	15.70	35.62	34.41	2.508
1	In full bloom	6.38	10.57	1.31	15.73	34.91	31.11	2.516	11.29	1.40	16.80	37.29	33.28	2.687
	Average..........	7.17	10.76	1.24	15.12	34.73	30.98	2.417	11.44	1.33	16.32	37.44	33.31	2.606
2	Coming in bloom.......	4,43	12.70	1.71	17.68	27.47	36.01	2.858	13.28	1.78	18.50	28.75	37.69	2.990
2	In half bloom..........	9.48	11.34	1.50	17.14	24.27	36.27	2.743	12.53	1.65	18.94	26.81	40.08	3.032
2	In full bloom...........	8.56	9.91	1.78	16.41	27.11	36.24	2.625	10.84	1.95	17.94	29.64	39.64	2.880
	Average...........	7.49	11.32	1.66	17.08	26.28	36.17	2.742	12.22	1.79	18.46	28.38	39.13	2.967
3	Coming in bloom.......	8.64	12.24	1.72	16.53	24.30	36.57	2.645	13.39	1.88	18.09	26.59	40.04	2.894
3	In half bloom...........	7.43	11.07	1.52	15.52	30.55	33.92	2.482	11.96	1.64	16.76	33.00	36.65	2.681
3	In full bloom............	8.36	10.66	1.83	15.59	30.18	33.38	2.495	11.63	2.00	17.01	32.94	36.42	2.722
	Average...........	8.14	11.32	1.69	15.88	28.34	34.62	2.540	12.33	1.84	17.29	30.84	37.70	2.766

For a large number of analyses and a discussion of the individual groups or fodder constituents see Bul. 35, p. 90, also pp. 13-25.

Relative Value of the Different Cuttings of Alfalfa.—I have stated in a preceding section that the usual practice is to cut alfalfa when it has not yet advanced to the stage of half bloom, though it is my opinion that the best general purpose hay is obtained by cutting it when it is in full bloom. There are good reasons why the practice of cutting it when in early to half bloom has come to be so generally adopted, but these reasons do not effect the subject discussed in this paragraph. I have also given the composition of the first, second and third cutting taken at the periods of coming into bloom, in half bloom and in full bloom, from which it appears that the extreme differences in the composition of alfalfa hay are less than they are frequently assumed to be. This fact explains the varying opinions held in regard to their relative values. There are some differences in composition but they are not big enough to produce the differences which come under the notice of the feeder. The analyses given in the preceding table, in my judgment, faithfully represent the composition of good Colorado alfalfa hay grown under average conditions for Northern Colorado. That the analyses given really represent the composition of Colorado alfalfa hay is evident from the following analysis which is the average obtained for the first cutting for three consecutive years; moisture, 6.86; ash, 10.65; fat, 1.54; protein, 15.00; crude fibre, 33.29; nitrogen-free extract, 32.12.

The above average is obtained from 19 closely agreeing analyses of first cutting alfalfa hay.

In the analyses given in the table it will be noticed that the greatest difference in the percentage of protein is 1.27 per cent and this is in favor of the sample taken when in full bloom over the one cut in half bloom. We are justified in assuming that the preceding analyses are thoroughly representative of the composition of alfalfa hay cut at these different periods, and we will neglect any error introduced by assuming that the whole of the nitrogen is present as proteid and consequently all of equal value. In the analyses given it appears that the hay cut when the plants were in full bloom contains the largest percentage of proteids. We have so many analyses showing this to be the case in our samples, that we believe that it is true for alfalfa hay grown under the average conditions obtaining in Northern Colorado. The difference is seldom so great as that shown by the hay cut in half bloom and full bloom in the analyses given. In the samples given each 100 pounds of the thoroughly dried hays would contain 16.5, 15.7, and 16.8 pounds respectively according to which, if the proteids alone be the standard of value, the hay cut in full bloom is the best, but pound for pound they are as I have before stated almost equal. While this series of analyses gives these results others will show the earlier cut hays to have slightly the advantage. But chemical composition is not the only consideration to be taken into account. The weight of hay cut off of an acre at full bloom is considerably more than the same acre would yield if cut in early or half bloom, probably from 10 to 15 per cent more. Regarding the degestibility of the hays made at the different stages of growth, using the proteids as our criterion, because we assume them to be the most valuable constituent, experiments show them to be very nearly alike, with a slight difference in favor of the hay cut at full bloom.

We found the coefficient of digestion of the proteids in hay cut at the period of half bloom, by artificial digestion, to be 79.30 and 79.60 and by animal digestion 73.7, 73.6 and 70.4. Artificial digestion seems to be fairly reliable though a little too high. The error, however, is likely to be in the same direction in the case of both samples, if so the hay cut at full bloom is slightly preferable.

As soon as alfalfa passes the stage of full bloom there is a decided fall in the amount of proteids present, the same is true of the nitrogen free extract. The loss of proteids amounts to about 2.5 per cent of the weight of the hay and the proteids are according to the results obtained by artificial digestion less digestible than at either early, half or full bloom.

Effects of Differences in the Seasons.—That there are differences in the hay from season to season, within comparatively narrow limits of course, due to the distribution of rainfall and variations in temperature, is a fact generally recognized. In speaking of this subject in Bul. No. 39 I conclude from a series of samples taken over a period of three years and representing hay grown on four different soils, that the composition of the first cutting is practically constant while that of the second and third cuttings is much less so, and in the latter we probably find the maximum variation that can reasonably be attribu-

ted to the differences in the seasons. These differences amount to three per cent for the crude protein, eight per cent for the crude fibre and about three and a half per cent for the nitrogen free extract.

Alfalfa Hay Easily Injured by Moisture.—In cases where the alfalfa has been cut and left in the swath, a light rain or even a heavy dew produces a discoloration. The hay has a light yellowish brown color and in general a bleached appearance. The amount of injury indicated by this color doubtlessly varies greatly and there is a variety of opinion about the value of such hay. In one instance in which some alfalfa was cut and, owing to a succession of showers, was not stacked till 13 days later, we found very considerable changes, but we were not able to determine the total changes, for we were unable to determine the mechanical loss in the weight of the hay. The differences shown by the analyses of samples taken as the hay was cut, and of others taken as it was stacked, showed a loss of more than one-third of the crude protein and one seventh of nitrogen free extract, accompanied by a very decided increase in the crude fiber, the percentage found in the injured hay being about 12 per cent higher than in the uninjured sample. The amount of rainfall was about 1¾ inches. Experiment shows that tepid water will dissolve 40.00 per cent out of first class, third cutting alfalfa hay; further, fermentation sets in readily. These properties readily explain the fact that alfalfa is very sensitive to moisture. The remaining hay may still be good hay, though its color is not inviting. There may, however, have been a big loss, the remaining hay weighing possibly only a little more than six-tenths as much as should have been gathered, from the crop as cut, not reckoning any mechanical loss, which will certainly have taken place.

Loss of Leaves, Etc., in Making Alfalfa Hay.—The general custom in this part of Colorado is to rake the alfalfa into windrows as soon after cutting as is at all advisable, and complete the necessary curing in windrow or cock as the case may be. This practice is the result of the observed loss of leaves and breaking off of small stems in raking and handling, if allowed to over cure in the swath. The loss, that is the leaves and stems which fall or are broken, amounts under favorable circumstances, to about one-fifth of the crop, and can if it is necessary to repeatedly handle the hay, amount to as much as two-thirds of the crop, which of course remains on the ground to enrich it.

The Relation of Hay Gathered to Green Alfalfa.—The amount or weight of hay gathered compared to that of the green alfalfa varies within comparatively narrow limits. With us 100 pounds of first cutting alfalfa gives about 27 pounds of hay, and 100 pounds of second cutting gives about 29 pounds. These figures do not agree at all with figures obtained for other States. The amount of hay obtained from 100 pounds of the green alfalfa, cut from early bloom to full bloom, has an extreme range of about four pounds. This is the case with the first and second cuttings.

The Relative Amounts of Leaves and Stems.—Some varieties of alfalfa are smaller stemed and leafier than others. The Turkestan

alfalfa as it grows with us is much leafier than our common alfalfa. Individual plants differ in this respect as much as the recognized varieties, so it is a difficult matter to obtain any figures which may be applicable except in individual cases. The best figures that we have been able to arrive at relatively to this subject, is that the leaves seldom if ever equal less than 40 per cent of the weight of the plant. and frequently make up 60 per cent of the weight of the plant. The rest of the plant is, of course, represented by the stems. This is an important consideration, for I have seen hay which has lost a very large proportion of its leaves before it was put into stack.

Importance of Saving the Leaves in Making Alfalfa Hay.—The preceding paragraph shows that we are justified in assuming that one-half of the weight of the plant as cut, is represented by the leaves. The importance of this fact in hay making becomes very apparent when we further learn that nearly four-fifths of the crude protein contained in the plant is found in the leaves, and only one-fifth in the stems. The leaves also contain considerably over one-half of the nitrogen free extract and fat, while the stems contain nine-elevenths of the crude fiber. It appears from these facts that the leaves contain very considerably more than half of those matters which we consider as of the most value as fodder constituents, i. e., the crude protein, nitrogen free extract and fat, on the other hand the stems contain almost 3-4 of the crude fiber.

This statement of these facts brings out the wisdom of the practice of raking the alfalfa into windrows as soon after cutting as is at all feasible, and stacking or putting it into the mow with as little handling as possible.

The Composition of Alfalfa Stems and Leaves.—It sometimes happens that the leaves are very largely shaken off, and the hay consists principally of the stems. I have seen such in the cock which was not unlike fine brush. The leaves in such cases are evidently lost as far as the hay making is concerned, but the stems make a fair hay, too good to be neglected, which is evident from their composition which is given below, together with analyses of timothy and native hays and alfalfa leaves.

	Moisture	Ash	Fat	Protein	Fibre	Nitrogen-Free Extract
Alfalfa Stems	5.71	4.99	0.85	6.35	54.32	27.79
Timothy Hay (Colo.)	6.49	9.34	2.99	5.62	31.54	43.99
Timothy Hay (Colo)	6.58	7.21	1.43	7.45	40.71	36.52
Native Hay (Colo.)	5.13	10.64	3.13	6.98	31.38	42.74
Alfalfa Leaves	4.93	14.48	2.96	23.33	13.15	41.16

The leaves are lost, it is true, so far as making hay is concerned but they add materially to the betterment of the soil. We never have hay consisting mostly of leaves, but in feeding sheep and cattle it is observed that they seem to prefer the leaves, and there is often a considerable portion of stems left. The preceding analysis shows that these stems are good fodder and a horse will eat them readily. The composition of the leaves is given in the preceding table.

Alfalfa Requires Water to Make a Good Growth.—Our average rainfall may be taken at 14 1-2 inches. In addition to this it requires from 6 to 8 inches of water per acre to grow the three crops usually cut in this section. Alfalfa is a deep rooted plant and will live when once established on high land even, with the addition of a small amount of water, but it needs the above amount of water to make a good growth.

Alfalfa Ensilage.—The considerable, unavoidable loss incurred in making alfalfa hay, say from 17.5 to 60 per cent of the crop, together with the desirability of having some succulent fodder, has led to experiments in making alfalfa silage. The silage is good and is readily eaten by cattle, the following analyses may be taken as representing its composition; moisture, 8.98; ash, 13.19; ether extract, fat, 2.93; crude protein, 14.18; crude fiber, 30.77 and nitrogen free extract 29.95 per cent.

Plant Food Required to Grow a Crop of Alfalfa.—The excellent results observed to follow putting land down to alfalfa for three or more years, leads to the conclusion that it enriches the soil. In a certain sense this is the case, and the practice of seeding run-down land to alfalfa and leaving it in alfalfa for several years before breaking it up again to plant other crops, has been the salvation of this section of Colorado, and yet it does not follow that the alfalfa plant does not require a large amount of plant food. The average percentage of crude ash in alfalfa hay is not far from 10.00 per cent, or in a crop of 4 1-2 tons, 9,000 pounds, there will be 900 pounds of crude ash, which will contain 39.10 pounds of phosphoric acid, 231.5 pounds of potash (K_2O), 62.8 pounds of chlorin, 208.8 pounds of lime (CaO).

There are but few crops which will equal the alfalfa in its draft upon the resources of the soil in which it grows, but while other crops gather their food from a depth of two, four or five feet, alfalfa gathers its food from depths ranging from six to twelve feet—so on the assumption that the alfalfa plant has no greater power to gather its food than the wheat plant, for example, it has, owing to the greater depth to which its roots penetrate, from three to four times the depth of soil to feed on. This is an essential advantage, especially if the upper portions of the soil from which the wheat plant has to draw its food has already been partially exhausted by repeated cropping, as has been the case in many instances in this State.

Most of our cultivated plants depend wholly upon the nitrogen stored in the soil for their supply, the alfalfa plant does so only in part, drawing a portion of its supply from the atmosphere. Though it may gather large amounts of this element from the soil, it probably returns more in the leaves that fall and the plants that die than it takes from the soil.

Benefits Accruing to the Soil.—The statements of the preceding paragraph may seem somewhat contradictory to one another, and apparently contradictory to what is an acknowledged and well established fact, i. e., that cropping to alfalfa benefits our soils, and does not exhaust it as one would infer from the amount of potash (K_2O) for in-

stance, which it removes. That the plant requires a large supply of plant food is very evident, for we find it contained in the plant, but its little feeding roots which gather this food are almost wholly below the depth at which ordinary crops feed, so this portion of the soil is resting while in alfalfa. Many of the plants die and rot, adding organic matter to the soil and facilitating the solution of the mineral constituents used by other plants. Not only do the plants die out, as is to be observed in almost any field of alfalfa, though I have seen some in which this was not apparent, but every crop grown adds materially to the upper soil by that portion of the plant which escapes being gathered as hay.

The Value of the Stubble.—The amount of leaves and stems which fall and rot on the surface of the soil each year is always considerable, and is, moreover, high in manural value, but the addition of fertilizing substances to the soil, which is effected by planting to alfalfa, is perhaps more strikingly set forth by the facts pertaining to the value of the stubble. The stubble of alfalfa taken to a depth of 6 1-2 inches, assuming an ordinary stand, weighs nearly 6 tons and contains over 36 pounds of nitrogen, equal to about 216 pounds of sodic nitrate, Chili saltpetre, in addition to 8 1-3 pounds of phosphoric acid and 15 1-2 pounds of potash. The alfalfa roots, however, reach a depth of 9, 10 and even 12 feet, on account of which the whole root system of the alfalfa can safely be credited, with twice as much nitrogen, etc., as is found in the stubble taken to a depth of 6 1-2 inches. The commercial value of this material is, at present prices, upwards of $35.00 per acre.

Stand of Alfalfa.—This means the number of plants in a given area, I believe that one plant to the square foot will grow as much hay and of as good a quality as any number of plants. We have determined the number of plants to the acre in a few instances and found it to range from 70,000 to 653,000. The hay cut from the field with seventy thousand plants was as desirable, and so far as one could judge from the appearance of the hay, as fine as that cut from a field having 562,000 plants to the acre, but if one considers the benefit to accrue to the soil the thicker stand is to be preferred, for there will be more roots to penetrate the soil and their aggregate weight will be greater while they will penetrate the soil to quite as great a depth. I have dug out a seedling alfalfa plant nine months old whose root measured 9 1-3 feet, while its diameter at the crown was a little more than one quarter of an inch. The stand in this case was very good, probably not less than 400,000 plants to the acre. The soil in this case was an open sandy loam and very deep.

Alfalfa Seed.—This seed varies considerably in size but the germinating power is usually high. The vigor of a young plant from a plump, mature seed is probably greater than that of a plant from a small, shrunken, immature one, but the germinating power of even immature seeds is high and their vitality is far greater than given in Bul. No. 35. The statements made in it were quite contrary to the

views entertained at the time they were made, but are very conservative in the light of the facts obtained since that time. The alfalfa seed in the highest state of perfection that I have seen it grown in Colorado, is of a greenish yellow color which it retains with but little change for years. I have some which I gathered 12 years ago and it is but little less bright, if any, than it was when I gathered it. I recently showed this seed to an expert in these matters who scarcely believed that it was not fresh seed and who, furthermore, declared that he had never before seen such alfalfa seed. I believe that we seldom obtain alfalfa seed which has attained its highest state of perfection. I quite recently purchased a sample of the best alfalfa seed obtainable in the open market and by actual count there is only 10 per cent of this sample nearly equal to the run of the 12 year old sample referred to above. The sample was purchased as choice seed at 15 cents per pound but the individual seeds were actually smaller than those in two samples of first quality screenings obtained ten years ago and grown at Rockyford, Colorado. The first quality seed purchased last season, 1905, run 288,267 seeds to the pound, while the samples of screenings run 259,340 and 266,233 to the pound respectively. The screenings are shriveled, probably because these seeds were immature when the plants were cut, and the plump, mature seeds have been separated by screening and winnowing.

The Average Yield of Alfalfa Seed.—This is not above five bushels per acre. A yield of 9 or 10 bushels is a big one and above this is exceptional. I have heard of as much as 14 bushels having been gathered, but a gentleman of large experience in growing alfalfa seed informs me that such a yield is very exceptional.

The Vitality of Alfalfa Seed.—Sometimes we fail to obtain a good stand of alfalfa, even though we use the amount of seed per acre which experience has shown to be sufficient, say 20 pounds to the acre. Such failures, a few years ago, were usually attributed to the lack of vitality in the alfalfa seed, especially if the seed were a little old. It was claimed that seed two or more years old had already so far lost its vitality as to be so good as worthless. This notion has prevailed a long while. Loudon says on this subject: "Great care should be had to procure it (Lucern seed) plump and perfectly new, as two year old seed does not come up freely." The following statement is made in North Carolina Bulletin No. 60: "The vitality of Lucern seed is so low that seed over one year old is scarcely worth sowing." This statement is supported by two sprouting experiments made with two year old seed, in one of which 6 per cent and in the other 12 per cent germinated.

I showed in Bul. No. 35 of this station, pages 41-44, that this is a mistake. I recorded on page 43 of Bul. No. 35 the result of 22 experiments in which I used 11 samples of seed ranging in age from one to six years. The 11 samples have been preserved and two series of experiments have been made with them since that time at intervals of four and six years—giving me a range in the age of the seed from 11 to 16 years.

Some of the samples (two) were kept in envelopes, the rest were kept in the specimen tubes in which they were put for the first experiment. During the first four years the samples were preserved in a table drawer in my sitting room, and for the last six years in a room in the basement of the chemical laboratory.

I will give the three series of experiments though the limits of this bulletin scarcely justify it.

No. 1. Prime seed gathered by myself.
No. 2. Prime seed purchased of Vandewark.
No. 3. Prime seed purchased of P. Anderson & Company.
No. 4. Prime seed furnished by J. E. Gauger.
No. 5. Prime seed furnished by J. E. Gauger.
No. 6. Prime seed purchased of P. Henderson & Company.
No. 7. Screenings, first quality, J. E. Gauger.
No. 8. Screenings, first quality, J. E. Gauger.
No. 9. Screenings, first quality, J. E. Gauger.
No. 10. Screenings, second quality, J. E. Gauger.
No. 11. Screenings, third quality, J. E. Gauger.

The following table of results is reproduced from Bul. No. 35, page 43.

RESULTS OF SPROUTING EXPERIMENTS—1896

No of Sample	Quality	Years Old	Number of Seeds to the Pound	Seeds Taken	Seed Rotted	Seeds Left	Seeds Sprouted	Average per cent Sprouted
1	Prime seed	2	206,837	100 100	0 0	0 8	100 92	96.0
2	Prime seed	2	228,818	100 100	1 0	9 6	90 94	92.0
3	Prime seed	2	208,021	100 100	1 1	7 0	92 99	95.5
4	Prime seed	2	....	100 100	1 5	13 5	86 90	88.0
5	Prime seed	3	....	100 100	0 0	2 1	98 99	98.5
6	Prime seed	6	....	100 100	5 5	1 3	94 92	93.0
7	Screenings, first quality	1	259,340	100 100	23 20	11 13	66 67	66.5
8	Screenings, first quality	2	344,123	100 100	42 29	7 11	51 60	55.5
9	Screenings, first quality	3	266,2.3	100 100	24 16	1 1	75 83	79.5
10	Screenings. second quality	2	331,3.3	100 100	59 58	7 5	34 42	38.0
11	Screenings, third quality	1	312,385	100 100	66 48	1 5	33 47	38.5

The results in this table show conclusively that neither of the requisites laid down by Loudon, that is, plump and new seed, are necessary so far as their germinating power is concerned and that the statement that two year old seed do not germinate freely, to say

nothing about the more extreme statement "that they are scarcely worth sowing," is altogether a mistake.

The screenings are composed of the small, immature and shrunken seeds. These seed are nearly all dark brown or green and shriveled—probably due to two causes; first because they were harvested while still very immature and second because they are infested with molds, at least molds develop readily during the sprouting experiments and many of the seed rot, but as the table shows such seed germinate freely even when two and three years old. Two years old screenings show a germinating power of 38.0 and 55.5 per cent, respectively, while a sample of three years old screenings shows a germination equal to 79.0 per cent. The variation in the quality of the screenings from year to year is shown by the varying number of seeds to the pound, which in the screenings of some years is smaller than that for seed sold as prime seed in other years.

The preceding table shows that a large percentage of the screenings rotted and that the percentage of seeds which rotted did not depend upon the age of the screenings but upon the samples themselves or the degree in which the samples were infested with the cause of the rot. It is strikingly evident from the table that none of the clean, hand-picked seed No. 1 rotted and only a few of any samples of prime seed, while as high as 59 and 66 per cent of the second and third quality screenings rotted. This rotting is most probably due to the fact that these seed were already infested by the bacteria and other organisms causing it before they were threshed. The samples of prime seeds and of screenings will not serve for the purpose of comparison from this point of view, because they are from different sources with possibly two exceptions.

I have observed, particularly in my last experiments, that when the seed rot, the screenings of samples 10 and 11 for instance, they appear to be glued together in bunches of three and four seeds unless they have been very carefully distributed and that any sprout, however vigorous and bright, is attacked and distroyed if it comes in contact with such a mass. The colorless mucilagenous mass enveloping the seeds is crowded with bacteria.

The samples of seeds used in the following experiments are the same samples used in 1896 except No. 12 of the series of 1906.

RESULTS OF SPROUTING EXPERIMENTS—1900

No. of Sample.	Quality.	Age in Years.	Seeds per Pound.	Per cent. Germinating.
1	Prime seed.................	6	206,837	92
2	Prime seed	6	228,818	80
3	Prime seed	6	208,821	70
4	Prime seed	6	......	78
5	Prime seed	7	......	66
6	Prime seed.................	10	......	72
7	Screenings, first quality	5	259,340	53
8	Screenings, first quality	6	344,123	25
9	Screenings, first quality	7	266,233	42
10	Screenings, second quality...	6	331,383	42
11	Screenings, third quality	5	312,385	25

No particular care or tricks of manipulation were used in order to obtain favorable results. If these samples had been sown in a good seed beds under favorable conditions the percentages of seed germinating would certainly have been as high as those given. I, of course, have no means of judging how many of the young plants would have failed to grow.

RESULTS OF SPROUTING EXPERIMENTS—1906

No. of Samples	Quality of Seed	Age in Years	Seed per Pound	Per Cent. Germinating	Average
1	Prime seed	12	206,837	94 91	92.5
2	Prime seed	12	228,818	84 80	82.0
3	Prime seed	12	208,821	73 76	74.5
4	Prime seed	12	......	70 76	73.0
5	Prime seed	13	......	66 66	66.0
6	Prime seed	16	......	69 57	63.0
7	Screenings, first quality	11	259,340	30 36	33.0
8	Screenings, first quality	12	344,123	21 11	16.0
9	Screenings, first quality	13	266,233	28 48	38.0
10	Screenings, second quality	12	331,383	11 17	14.0
11	Screenings, third quality	11	312,385	14 14	14.0
12	Prime seed	2	288,267	65 70	67.5

Four other experiments were made with sample No. 1, because I gathered this seed myself in the summer of 1894 and the preceding tables show that in 12 years it has lost only 2.5 per cent of its germinating power. The results at the end of five days were as follows:

Seed Taken	Rotted	Hard Seeds	Seeds Sprouted
100	4	4	92
100	1	5	94
100	1	4	93
100	1	1	98

The average of these four experiments is 94.25 per cent which is very nearly as high as the result obtained with this sample in 1896 when it was only two years old. The results obtained with this sample, 96 per cent germinating when the sample was two years old, 92 per cent when six years old, 92.5 to 94.25 per cent when it was 12 years old, show that good, plump, mature, clean alfalfa seed does not lose its vitality rapidly when kept with ordinary precaution to prevent injury from moisture.

Sample No. 6 shows quite a deterioration in the 10 years lapsing between the first and last experiment. When six years old this sample showed a germinating power of 93 per cent, though it had been kept

in a small bottle in a show case, exposed to a strong light and to all the changes of temperature for five seasons in Colorado; when ten years old showed a germination of 72 per cent and when 16 years old a germination of 63 per cent. The conditions under which this sample has been preserved, especially during the first six years, were less favorable for the preservation of its vitality than would ordinarily be the case. So I think it safe to conclude that the limit for the vitality of good, mature alfalfa seed exceeds 16 years.

The screenings, as will be seen by referring to the tables, stand in the same relative order of vitality that they did ten years ago. The deterioration, however, is very marked for all of them. The screenings rotted badly in 1896, worse in 1900 and still worse in 1906.

In the experiments of 1896 as many as 60 per cent of them rotted while in those of 1906 as high as 86 per cent of the same sample rotted. I have previously stated that bright, vigorous sprouts were destroyed by coming in contact with the rotting seed and owing to this fact, I doubt whether any plants would have survived, had the seed been used for actual planting. I endeavored to prevent the rotting by wetting the upper piece of blotting paper with a solution of bichloride of mercury but when I stopped the rotting I practically stopped the sprouting. My solution was evidently too strong. I also made separate tests on samples No. 7, 8, 9 and 10 by first soaking them in pure water for two and a half hours and then for forty minutes in the bichloride solution; this prevented the rotting but evidently injured the seed as the results clearly show, of No. 7, 10 per cent. of No. 8, 1 per cent, of No. 9, 4 per cent and of No. 10, 3 per cent sprouted. Some of these sprouts were not strong but they were bright and healthy looking; they did not rot like the others.

I call especial attention to sample No. 12 in the series of 1906 because it shows how different lots of this seed may vary. This sample was obtained in 1905 as a sample of prime, fresh seed, but the best of the seeds were small. It required 288,267 of them to make a pound, whereas, of No. 9, first class screenings, it required 266,233 seeds to make a pound. Only 42 per cent of No. 12 were good, bright seed and only 10 per cent of the sample could be classed as good, bright, plump seed, and these 10 per cent were smaller, actually weighed less, than the average seed of sample No. 1. The 58 per cent were small, green or brown and many of them shriveled. This 58 per cent would have been removed by proper cleaning. The results of the sprouting experiments indicate this clearly for 79 per cent of No. 9 sprouted when the seed was three years old and only 67.5 per cent of No. 12 sprouted when the seed was two years old. I may further remark that this sample, No.12, rotted badly showing that the rotting is due, as previously suggested, more largely to the sample than to its age.

The Size and Length of Alfalfa Roots.—There is no subject on which a greater variety of statements can be found than on this. The alfalfa root system as it develops in our soil is very simple as shown by the illustrations in Bul. No. 35. It consists of a tap root

with very few small side roots. Nothing in connection with this plant seems more marvelous to me than the fact that the simple, root system of this plant can produce such a luxuriant growth of top. The average root, even at the crown, is less than 1-2 inch in diameter but I believe that the shortest normal root that I have dug up was about 6 feet long and the longest one 12 1-4 feet. Their ability to penetrate hard soil is very great, but of course there are instances in which some of the roots fail to penetrate hard layers. The average reader will understand that by hard soil I do not mean rock, still I have followed roots through layers of such tenacity that a pick was indispensible in removing the earth—and while the root was sometimes twisted and crooked it was usually of good size and always healthy.

Anyone desiring a fuller discussion of these and many other points relative to alfalfa will find it in Bulletin No. 35, to which I have had occasion to refer repeatedly.

Bulletin 111 **May, 1906**

The Agricultural Experiment Station

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Alfalfa

(A SYNOPSIS OF BULLETIN NO. 35)

—BY—

WM. P. HEADDEN

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ALFALFA

(A SYNOPSIS OF BULLETIN NO. 35.)

BY WM. P. HEADDEN

Bulletin No. 35, issued in 1896, is still in constant demand. This bulletin consists of nearly 100 pages, and covers a large part of the matters relating to this valuable plant. Because of its size, however, and its not being indexed, it is difficult to find a fact or statement to which one may wish to refer. Further, because of the unusually large edition issued, and the cutting down of the mailing list made at the same time, there- a large excess, of which a number still remains. A synópsis, such as is here given, will take the place of an index and will be useful both to those who already possess a copy of No. 35 and to those who may in the future receive one. This synopsis is therefore prepared as a supplement to bulletin No. 35. Owing to its size it is not likely that No. 35 will be re-issued, as bulletin 110, and this synopsis, will fill its place, so far as the demands of the general public are concerned.

Copies of the original bulletin may still be obtained on application.

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OBJECT AND SCOPE OF BULLETIN 2

HISTORY OF ALFALFA 2-4

Description of the plant; native place, probably Media, whence the name Medick; introduced into England 1650; cultivated by Greeks and Romans; culture has not been continuous in Italy; brought to South America by the Spanish; brought from Chili to California in early fifties; 1854; brought to Colorado in the early sixties, 1862-3(?).

CULTURE 4-8

Methods in vogue essentially the same as have been in use for centuries. Methods differ slightly for different soils and climates. Cold, wet winters and poor drainage constitute bad conditions for cultivation of this plant. It is customary to sow with a protective crop.

Seed.—Screenings produce good stand of healthy plants, sufficient to produce maximum crop. Seed bed should be deeply prepared and plants receive abundant water during first season. Tap roots not always present. Transplanting has been practiced with good results. Three cuttings made in England and seven in Catalonia. Alfalfa yields better hay when sown broadcast than when sown in drills. Life of the plant is given as from two to fifty years. Alfalfa needs water to produce a crop. Its long roots may enable it to live without much water, but not to produce a good growth. Alfalfa does well in a wide range of soils; also of altitude.

VARIETIES 8-9

Two varieties, at least, in alfalfa as grown in Colorado; one has red stem, small, dark green leaves and dark purple blossoms; the other has green stems, large and lighter green leaves, and lighter blossoms. The red stemmed plants are earlier and leafier than the green stemmed.

Three French varieties experimented with did not retain their distinctive features.

Turkestan alfalfa experimented with did not change its character.

There are but slight differences in the composition of e varieties.

COMPOSITION OF ALFALFA, HAY, LEAVES, STEMS, ETC. . . 9-32

Preparation of samples.

Samples dried in the air and at 100° show no difference in composition. It is not well to dry above 100°, page 9.

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Samples taken before bloom, beginning bloom, half bloom, full bloom, with seed formed and with mature seed.
Samples of flowers, leaves, stems, roots, etc.

Proteids in Alfalfa at Different Periods of Growth and in Alfalfa Hays at Different Cuttings 10-11

The average percentage of proteids found in our laboratory samples, were: in first cutting alfalfa, about 14.0 per cent.; in the second cutting, 14.43 per cent.; in the third cutting, 13.05 per cent. In the farm samples, first cutting, 14.92 per cent.; second cutting, 13.99 per cent.; third cutting, 13.47 per cent.

Analysis of Alfalfa Hay as Cut and of the Same Damaged by Rain 12

As cut, ash, 12.18; crude fat, 3.94; crude protein, 18.71; crude fibre, 26.46; nitrogen free extract, 38.71. Damaged by rain: Ash, 12.71; crude fat, 3.81; crude protein, 11.01; crude fibre, 38.83; nitrogen free extract, 33.64.
First cutting hay contains more proteids than second or third cutting.
Amount of proteids is nearly stationary from beginning to half bloom, and decreases after full bloom.

Crude Fibre 13-16

Percentage of crude fibre varies a little, due to varieties; also to conditions of soil and moisture.
Percentage of crude fibre increases with age of plant, but is fairly constant from the period of early to full bloom.
Percentage of crude fibre in supposedly distinct varieties grown in drills was the same as in ordinary hays.
Percentage of crude fibre in second cutting hay is essentially the same as in the first cutting.
The percentage in third cutting varies more than in the others, but averages about the same.

Fat or Ether Extract 16-17

The average percentage extracted is 1.539 per cent.

Nitrogen Free Extract 17-19

Average percentages obtained from labratory samples were:
For first cutting hay 31.69
For second cutting hay 34.27
For third cutting hay 32.72
Average percentages obtained from field samples were:
For first cutting hay 34.35
For second cutting hay 34.04
For third cutting hay 34.74

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Moisture in Air Dried Hay 18

The moisture in the laboratory samples averaged 6.03 per cent. the field sample, 7.09 per cent.; under ordinary Colorado conditions the average will not be far from 6.5 per cent. Air dry alfalfa hay under our usual conditions absorbs moisture rapidly. One ton of ordinary air dry hay will readily absorb 114 pounds of moisture during a damp spell.

Ash or Mineral Constituents 19-21

The amount of ash present in alfalfa hay varies but slightly. The average for the first cutting is 9.08 per cent.; for second cutting 10.24, and for the third cutting 9.83 per cent. for our laboratory samples. The results for the field samples were a little higher, 11.19, 10.48, and 10.07 per cent. for the respective cuttings. These figures are for the pure ash. A five-ton crop of alfalfa removes about 1,025 pounds of ash or mineral matter.

Water in Alfalfa 21-22

The average percentages of water in the first and second cuttings are 73.14 and 71.08. The water in the third cutting was not determined. Other determinations for the first and second cutting gave 74.76 per cent. for the former, and 72.80 per cent. for the latter. One hundred pounds of green alfalfa, first cutting, makes about 27 pounds of hay; and 100 pounds of second cutting makes about 29 pounds of hay.

Amids, Amid Nitrogen 22-25

The amid nitrogen in the first cutting of alfalfa hay corresponds to 10.85 per cent. of the total crude proteids or albuminoids, and 19.93 per cent. of the total in the second cutting, while we found but 5.03 per cent for the third cutting.
Colorado samples differ greatly from Texas samples given in Texas Bulletin No. 20, 1892.
The amids probably reach their maximum at about the period of half bloom, as they begin to disappear as the plants go out of bloom.
The bloom itself is rich in amids (see p. 28 for analysis). About 20.28 per cent. of the total albuminoids being amids.

Nitrogen as Nitric Acid 25

Nitrogen is not present in this form—the result of 18 tests.

PARTS OF THE PLANT 25-32

Stems p. 25.—Average diameter, 0.17 of an inch; height five and one-half feet under favorable conditions. Proportion from 40 to 60 per cent. of the plant; the rest of the plant is represented

PAGE

essentially by the leaves. The fresh stems contain about 60 per cent. of their weight of water. The mechanical loss in making alfalfa hay is from 15 to 20 and even 66 per cent. Composition of alfalfa stems is that of a fairly good hay, p. 26. The amid nitrogen in the stems is very low.

Leaves, p. 27.—Alfalfa leaves affected by a fungus, p. 27. Fresh leaves contain 68.72 per cent. of water. The leaves are very rich in proteids up to half bloom, but are not so rich when past full bloom.

The amids in the leaves are high, about 15.65 per cent. of the total albuminoids.

The percentage of ash in the leaves is high, about 14.00 per cent.

A large percentage of the leaves is lost in hay making, (p. 26).

Flowers, p. 28.—The flowers are important as they indicate the turning point in the development of the plant. The fresh flowers contain 72.69 per cent. of water. The composition of the flowers is similar to that of the leaves.

Analyses p. 28.—The amids are more abundant in the flowers than in any other portion of the plant. The flowers are not sufficiently abundant to account for the large amount of proteids in the hay cut when the plants are in half bloom. The ether extract of the flowers is not very high and does not foreshadow the large amount of oil in the seed.

REVIEW OF QUESTIONS RELATING TO ALFALFA HAY MAKING 29-32

The time of cutting; the influence of irrigation; the influence of growing on high and low lands; comparison of results obtained in Texas, New Jersey, and Colorado. The composition of the various cuttings shows but little variation.

Composition is not the only factor in making a good hay.

Analyses of alfalfa hays, laboratory samples, made from plants at different periods of development, grown without irrigation, on low land and on high land, p. 31.

Analyses of parts of the plant grown under same variety of conditions, p. 31.

Analyses of alfalfa hays, farm samples, p. 32.

ALFALFA AND CLOVER HAY COMPARED 32-33

Analyses of clover and alfalfa hays, p. 32. Green alfalfa yields 2.5 per cent. more hay and contains about 7.00 per cent. more digestible food than clover.

ALFALFA, RED CLOVER AND PEA VINE ENSILAGE COMPARED 33-34

The dry matter in alfalfa ensilage is 30.19 per cent. Analyses

PAGE

of alfalfa, pea vine and clover ensilages, p. 33. The pea vine ensilage was made from pea vines after the peas had been threshed out for canning purposes. The ash in alfalfa ensilage is much higher than in the hay, indicating a considerable loss of dry matter.
Alfalfa ensilage is eaten freely by cattle. The so-called "brown hay" is alfalfa hay which has passed through a fermentation in the stack and is considered an excellent fodder for cattle. Alfalfa ensilage is easily damaged by putrefactive fermentation.
Analysis of damaged alfalfa ensilage, p. 34.

PLANT FOOD TAKEN FROM THE SOIL BY ALFALFA 35-37

Leguminous plants such as alfalfa are considered as nitrogen gatherers, and when they are incorporated with the soil in which they have grown add nitrogen to it, but when they are removed it is questionable whether this is so or not.
The ash content obtained from our samples probably represents the normal amount which a healthy alfalfa plant will take up.
Table showing the pounds of the various plant foods removed by 1,000 pounds of alfalfa hay. One ton first cutting alfalfa hay removes 143 pounds of ash constituents; one of second cutting, 165 pounds, and one of third cutting, 127 pounds. Carbon, carbonic acid, and sand not reckoned. One ton clover hay removes 128 pounds of ash constituents.

ALFALFA SEEDS 37-44

Analysis of seeds, p. 31; analysis of ash, p. 92. Description and size of alfalfa seed, prime seed, 1st, 2d and 3d quality of screenings, p. 38. Amount of seed sown to the acre, p. 39.

WHAT CONSTITUTES A GOOD STAND OF ALFALFA 39-40

Hay produced by single plants in thick and light stands. Number of stems thrown up by individual plants, p. 41. Stems produced by plants having much space are not larger than those produced by plants which are crowded; the size of the stems is influenced by other conditions. The amount of seed necessary to produce a good stand depends upon the vitality of the seed and the vigor of the plants produced.

VITALITY OF ALFALFA SEED 41-44

Alfalfa seed said to be low in vitality. Experiments made to refute this statement. Description of samples of seeds used. How the experiment were made. Results of experiments p. 43. "Hard Seed" explained and germinating power given, p. 43. Duration of experiment, three days, sufficient to form

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a judgment of the value of the seed. Six-year-old alfalfa seed had lost but little or none of its germinating power. Screenings give good results even when two or three years old. Failures to obtain a stand are due to causes other than the lack of germinating power of the seed.

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Depth Attained by the Roots.

The depth attained by alfalfa roots varies with the soil; it may also be determined by the height of the water plane. Alfalfa roots are more tolerant of water than popularly supposed. Illustrated in Plate XIII.
Locality in Weld County chosen for digging out samples of alfalfa roots, p. 48. Section of soil given, p. 48. Plants were five or six years old and vigorous. Roots had penetrated the hard layer and did not divide. Depth reached was eleven feet nine inches, ending in a soft sandy clay. At the next place chosen the soil was nearly uniform to depth attained by roots. This soil was a clay and was formerly used for making brick. Age of these plants five or six years; length of roots twelve feet three inches. Effect of raising the water plane, p. 49.

Effect of Age on Size of Roots 50

Observations show great variation; some nine months old roots are larger than others six years old.

Death Rate of Roots 50

In five years from seeding two-thirds of the plants had died. The yield of hay not affected. Dying out of the plants or thinning of the stand not objectionable provided it is uniform. The plants die in two ways, p. 51. The second mode of dying illustrated by plates XV, XVI and XVII. Alfalfa roots when cut off below the crown do not bud and reestablish the plant, and their power of throwing out adventitious roots is small.

Alfalfa Roots Cut by Gophers 52

Alfalfa plants endure this root pruning to a remarkable extent.

Nodules on Alfalfa Roots 52-53

These occur in three forms; as warty excrescences on the roots, in large colonies, and as single nodules. The first

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form occurs near the surface; the second is most abundant at depths of from three to five feet; and the third at all depths up to eleven and a half feet. Illustrated in Plates XI. and XIV.; also shown in Plate XIII. Partial analysis of nodules page 53.

Ratio of Roots to the Tops 53-54

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Alfalfa Stubble 55

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Mineral constituents per 1,000 pounds of stubble, page 56.

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Analyses of ash of roots, bark, and inner portion, page 92. Methods of preparing roots—could not wash them, page 56. Fresh roots contain 60.41 per cent. water. Fodder analyses of root, page 57. Ash constituents are easily washed out of the roots. Properties of aqueous extract of roots, page 57. The presence of starch doubtful. Mineral plant food contained in each 1,000 pounds of air dried roots, page 58. Ash constituents dissolved out of roots by water equal 11.99 pounds per thousand. Phosphoric and sulphuric acids, but particularly potash, went into solution.

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Each ton of stubble contains 8.31 pounds of phosphoric acid, 15.52 pounds of potash. 36.37 pounds of nitrogen; giving the value of the stubble at $6.75 per ton, or $19.28 per acre.

Manurial Value of the Roots 60

The weight of roots per acre is nearly twice as great as that of the stubble, but is not so rich in phosphoric acid and nitrogen; the manurial value of the roots per acre is about $16. 58. Without assigning any value to the organic matter we have $35.90 as the value of the alfalfa stubble and roots. This food is within the reach of ordinary plants; wheat for example. If the alfalfa roots were removed, the soil would be found poorer than before the alfalfa was grown on it, especially in nitrogen, the first nine inches of soil excepted, page 61.

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THE LEAVES AND STEMS AS A TOP DRESSING 61-63

The leaves and stems which fall on the ground to become incorporated with it amount to about one ton a year, which accounts for the fact that the first nine inches of soil in which alfalfa had been grown was found to contain more than half the nitrogen contained in the soil to a depth of nine feet, 8.9 pounds out of 17.0 pounds in all. There is an accumulation of plant food in the upper portions of the soil which is of material benefit. Elements of plant food contained in 1,000 pounds of leaves, page 36. Fodder analyses of leaves, p 27. Analyses of ash of leaves, p. 92. Fodder analyses of stubble and roots of alfalfa, p. 63. Analyses of ashes of stubble and roots, page 92. Elements of plant food in 1,000 pounds of stubble and roots, page 63.

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Bulletin 112 April, 1906

The Agricultural Experiment Station

OF THE

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A Hopperdozer

—BY—

P. K. BLINN

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A HOPPERDOZER

By P. K. Blinn

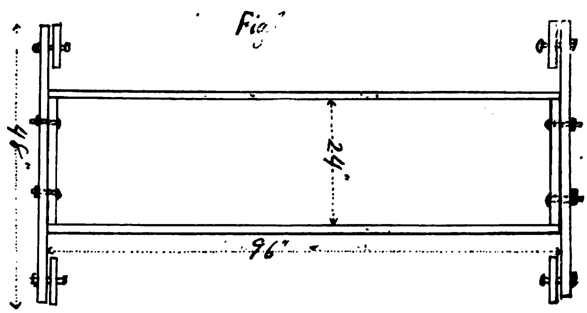
Our native grasshoppers have been a common pest in the alfalfa fields for many years, principally infesting the edges of the fields, along side of dry ditch banks, fences, or other dry land, such locations affording their favorite breeding places. For several years it seems that the "hoppers" have been rapidly increasing. Their injuries to the hay crops, alfalfa seed and honey yield of the state amount each year to many thousands of dollars, beside the serious injuries to beets, beans, potatoes, cantaloupes and most other crops that may be growing adjacent to the field of alfalfa to which they are attracted each time after the hay is cut.

The extent of their injuries the past season was unusually severe and quite general over the state. In the Arkansas Valley the alfalfa was almost stripped to stems in many fields, and the destruction of the bloom was so complete as to practically destroy the alfalfa seed crop east of Pueblo. The loss of the bloom also cut off the honey crop from one of the choicest honey producing sections of the United States, many of the apiarists being compelled to feed their bees during the summer months. Serious injuries were also made on nearly all other crops by the grasshoppers from the alfalfa fields. The farmers resorted to spraying, driving and poisonous baits, as well as other precautionary measures, but with only meagre results.

Having observed the shifting movements of the grasshoppers when the alfalfa is cut, it seemed evident that such a time offered a favorable opportunity to destroy the pest. It seemed that a hopperdozer could be used effectively behind the mower; accordingly a dozer was constructed on rather an inexpensive plan, one which any farmer with ordinary tools could make without the aid of a skilled mechanic.

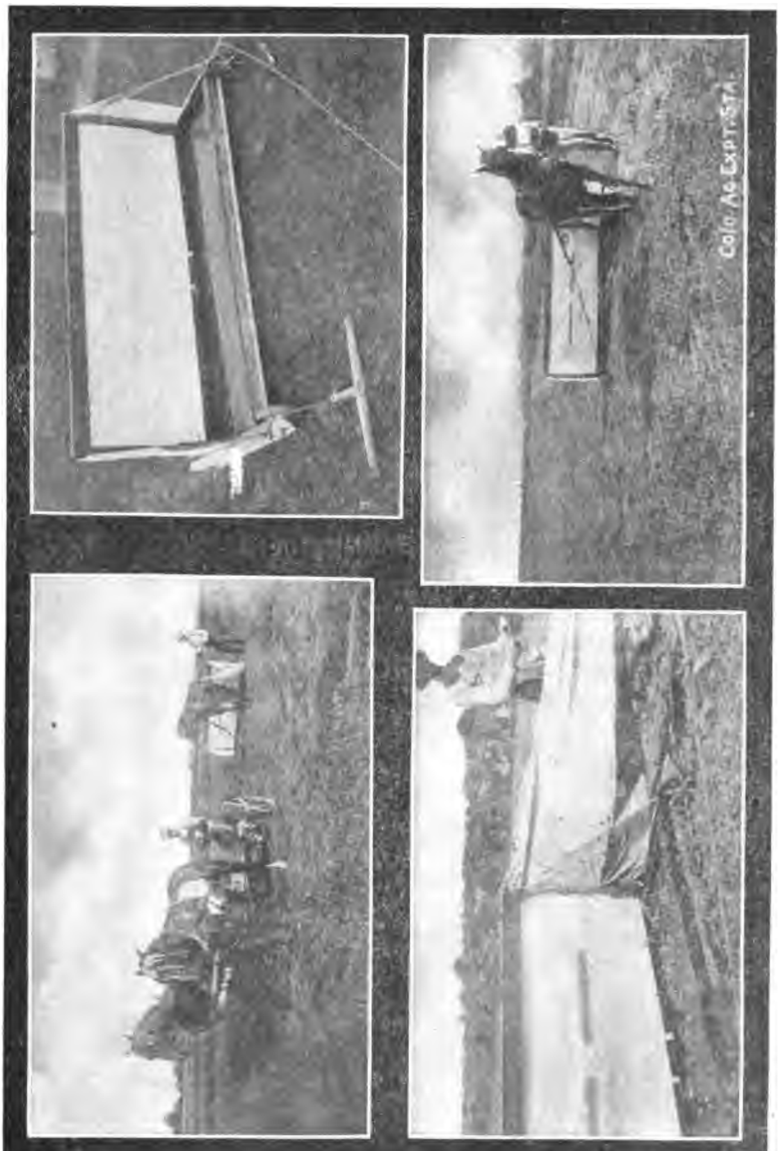
The bottom of the pan was a sheet of No. 24 galvanized iron 30x96 inches, the size of sheets usually carried by hardware dealers.

This bottom was nailed with common six-penny nails to a frame made of two-by-fours that was 24x96 inches in size and being the same in length as the sheet of iron, but about six inches narrower, which allowed about three inches to be turned up and nailed to the outside of the frame on each side. This made the pan more secure. To prevent leakage a strip of tow candle wicking was nailed beneath the iron between two rows of nails.



A coat of paint completed a water tight pan 24 inches wide inside by eight feet long. To the ends of this pan were bolted sled runners four feet long, cut from a piece of 2x10. The runners were so placed as to carry the pan about four inches above the ground. Fig. 1 shows the general plan of the pan with the runners attached, also four small 10 inch cast wheels bolted near the ends of the runners, also the dimensions as indicated. The wheels support the runners only one and a half inches and steady the pan over rough places. They lightened the draft and allowed the pan to be drawn over the hay without catching and dragging it. By hitching a horse in front of one runner with a short rope and with a longer rope from the other runner hitched into the hame staple of the harness, the wheels will carry the dozer at right angles and entirely to the side of the horse, thus preventing the hoppers from being frightened away from in front of the advancing pan. At the back of the pan is a light frame three feet high secured by uprights that are braced in front to the runners. Over this frame is stretched a sheet of white table oilcloth with the smooth side to the front. Every grasshopper that hits the smooth surface of the oil cloth screen falls into the pan which is filled with about two inches of water and about a pint of kerosene oil on the surface. The lower edge of the oilcloth is nailed with strips to the inside of the pan at the back to prevent slopping.

Plate I. shows the hopperdozer complete ready to hitch to and also views of it when in use and the manner of hitching.



Hopperdozer
Manner of Hitching Horse

Following the Mower
Near View, showing Pan

The material and its cost to build the dozer at Rocky Ford was as follows:

One sheet of No. 24 galvanized iron, 23 lbs. at 9 cts.	$2.07
" piece of 2x4, 16 ft.	
" " " 2x4, 8 ft.	
" " " 2x10, 8 ft.	
" " " 1x4, 16 ft.	
Total 32 ft. at 2½ cents	95c
3 yards of table oilcloth at 18 cents	54c
4 cast wheels	50c
Bolts, nails and rope	40c
1 ball candle wicking	10c
Total cost	$4.56

The hopperdozer was first tried on Mr. J. R. Roth's six acres of alfalfa east of Rocky Ford, the field being so infested that in the evening when the hoppers climbed to the top of alfalfa stems they gave a yellow cast to the otherwise green field. They had completely destroyed the alfalfa bloom and the adjoining fields of potatoes and beets, and cantalopes were threatened as soon as the alfalfa should be cut. After getting a start of several swaths with the mower, the dozer was started. The first round with the dozer the horse walked outside of the alfalfa while the dozer covered the first two swaths of the mower. The movements of the horse frightened the hoppers from the edge of the field into the pan or farther into the field to be caught at some succeeding round with the dozer. In the first two rounds, a half bushel measure of grasshoppers was skimmed from the pan; more water and oil were added, and the work continued to the center of the field, catching the hoppers more rapidly at each succeeding round. The last two swaths were so covered with hoppers that the mower was stopped and the dozer driven over this standing strip with the horse on a trot. The strip was about eight feet wide by seven hundred long, and once over and back on this strip, caught three heaping half bushels of grasshoppers. Many of the hoppers were down in the hay and after about fifteen minutes they had crawled to the top, and covered the strip again, and again the drive was made and two half bushels was the result.

The strip was left standing for several days and the dozer run over it several times each day catching many of the hoppers that remained on the field.

The dozer was run over the field several times the day it was mowed and between nine and ten bushels of grasshoppers were caught besides many that got out of the pan but died from the effect of the oil bath. A careful count of the number of grasshoppers

in a given measure was made and it indicated that over thirty thousand grasshoppers were killed in each bushel caught. A large part of them were very small hoppers and only a few, at that time, July 11th, had developed wings. Many alfalfa worms were caught when the dozer was run over standing alfalfa. The field has since been comparatively free from hoppers and no apparent injury was made on the adjoining crops.

About ten days later the dozer was used on the field of Mr. J. B. Fyan. The hoppers had then developed wings so that many were able to fly too far, thus preventing a very successful catch, although several bushels of grasshoppers were killed on about two acres of alfalfa. Other farmers used the dozer and several other dozers of similar construction were built and used in the vicinity of Rocky Ford. In fields where the grasshoppers were unusually numerous, satisfactory results were made, yet it was evident in the experience of all that the dozer could be most effectually used early while the hoppers were small and could not fly, and especially where the dozer was driven rapidy over standing alfalfa from 8 inches to 12 inches high; although it was demonstrated that large full grown grasshoppers could be caught and killed in the same manner early in the morning after a shower or heavy dew when the hoppers would be wet and numb from cold and too stupid to fly.

Early one morning in August, after an evening shower, the writer observed that a piece of alfalfa was literally yellow with grasshoppers that had climbed to the top of the stems to catch the warmth of the first rays of the morning sun. A horse was immediately hitched to the dozer, and coal oil not being handy the pan was filled with cold water only from a ditch near by and the horse driven at a trot through the standing hay which was about 12 inches high. It was 40 rods across the field and back and by that time the pan was full of grasshoppers struggling in the water. These were immediately skimmed out with a screen and thrown into a milk can and the cover put on. After the second trip the can was more than full of grasshoppers pressed in tight. As there was no oil on the grasshoppers the can was carried to the yard where a flock of young chickens and turkeys fairly covered the can after it had been turned on one side, with the cover off, and they had discovered what it contained. The following morning being wet and cold, we took an early start and in less than a half hour we had killed over four bushels of large grasshoppers on less than two acres; this time we used coal oil, as many hoppers seemed to escape when only water was used.

The amount of oil required, will not exceed a gallon to the

acre and usually much less. The oilcloth screen at the back of the dozer is an important feature as it does not allow the hopper to stick to it and those that hit it fall into the pan and are killed.

The wheels attached to the runners lighten the draft and enable one horse to pull the pan to one side as explained and shown in Plate I., and also allows the pan to be drawn through standing alfalfa without trickling it down to any extent. For larger fields a longer pan, say from 12 to 16 feet, would doubtless be more economical, but a long pan would need divisions to prevent the water from flowing to one end on steep ground.

A good example of the destruction of grasshopper eggs by early spring or winter discing of the alfalfa fields, was seen on the farm of Mr. C. J. Cover. His field was purple with bloom with comparatively few grasshoppers while all neighboring fields had been stripped of bloom by grasshoppers.

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Larkspur and Other Poisonous Plants.

BY GEO. H. GLOVER.

According to the last statistics, there are something over $50,000,000 invested in live stock in the State of Colorado. The old open range conditions still prevail to some extent, and many of the vexatious problems which have hampered this industry from its inception remain unsolved.

I deem it no presumption to say that there is no place on the face of the earth where the live stock industry flourishes less hampered by disease, contagious or otherwise, than in the salubrious climate of the arid west.

Not one of the great animal scourges that have decimated the herds of the Orient for centuries, and some of which have in the past reached our eastern shores, have ever found their way west of the Mississippi river, thanks to an eternal vigilance on the part of the Federal and State authorities. The loss we suffer is not great from any one specific cause, but in the aggregate become a heavy burden.

It has been estimated that the loss from poisoning of stock on the open range in the State of Montana is at least $100,000 annually. In this State it must be nearly or quite as great. The aggregate value of the animals actually lost does not, however, begin to represent the loss actually sustained by the industry because of the presence of a few species of poisonous weeds. In many sections of this State ranchers have given up in despair and been forced to abandon otherwise ideal ranges. The animal mortality, combined with the injury done to those animals not actually destroyed, have curtailed the profits until the owner at last is forced into bankruptcy and the ranges are abandoned.

Until the last few years no systematic effort has been made to investigate these poisonous plants of the western ranges. Their identity, poisonous nature, and remedy was simply a matter of common report among the stockmen.

In 1901 the U. S. Department of Agriculture sent two experts (Chesnut and Wilcox), to Montana to investigate the plant poisoning of stock in that State, and their report has been of inestimable value not only to the live stock industry of that State but to the whole country, more especially to the arid West. Other

bulletins from various State experiment stations, notably North Dakota, Idaho, Montana, have followed, and not only been of great practical benefit to the stockmen in identifying the most dangerous of these plants, but seems to have aroused the spirit of inquiry on the part of scientists for more extended research regarding them.

This bulletin is issued with the view of placing before the farmers and stockmen of the State a plain and concise statement, with illustrations, regarding larkspur and a few of our most common and most to be dreaded range plants.

Early in the spring of 1905 the Colorado Experiment Station undertook a co-operative experimental investigation of loco and larkspur with the Department of Agriculture. The work with loco weeds has been carried on throughout the summer and fall, with headquarters at Hugo, Colo., under the direct supervision of C. Dwight Marsh, of the U. S. Department of Agriculture, and the report will follow in due time.

Poison weeds in general throughout the State, with special reference to larkspur, has been the subject of special inquiry by the Experiment Station, at Fort Collins, and in this investigation has been ably assisted by the Bureau of Plant Industry, at Washington, by way of identification of plant, chemical analysis, determination of lethal dose, etc.

Out of the large number of plants known to be poisonous under certain conditions the two loco weeds known as white and purple loco, and several species of larkspur, have been singled out for special investigation at this time as they are held responsible for at least ninety per cent. of the loss in this State. While scattering reports come in from various sections of the State of loss which can be attributed only to camas, lupin, hemlock, and various others, in the great majority of cases it is from the loco weeds in the eastern half of the State and larkspur in the mountainous regions. Nearly every community of the State has been visited within the last year, and a fair knowledge of the most prevalent poisonous weeds obtained. In visiting various sections of the State, and by correspondence as well, I find that unless the plant under discussion is at hand there is no certainty that we both have the same plant in mind. There is no general agreement among stockmen themselves either as to the common names, identity, or symptoms from poisoning of even our most common poison weeds. White loco weed and rattle weed are spoken of as different plants; larkspur is commonly called aconite; death camas as wild onions, etc. I have corresponded with different parties with reference to the loss sustained from larkspur, and upon receiving the specimens found them to be something entirely different. This, however, simply causes some inconvenience. It does not present a serious

obstacle to their investigation, but incidentally furnishes an indisputable argument in favor of the necessity of educating the stockmen as to their identity in order that they may the more effectually avoid them.

In the realm of toxicology we are still groping in the dark, and our best scientists have laid down before many of the stupendous obstacles confronting them and acknowledge defeat. Here are some of the difficulties with which we have to contend:

1. *Some Plants Are Poisonous Only at Certain Stages of Growth.* The lupine (wild pea—horse beans), are found growing in almost every section of the State and in great abundance on the Western Slope, and in many places are cut for hay; they are poisonous only at the time of going to seed. Larkspur (*Delphinium*), is very deadly early in the spring, and loses its toxicity almost entirely at flowering time. The death camas (*Zygadenus venenosus*), growing from a poisonous bulb, is very deadly early in the season, but gradually becomes less harmful and dries up in July. Sorghum and kaffir corn, which became popular forage crops in the non-irrigable sections of eastern Colorado, have produced such disastrous results from feeding green at certain stages of growth that their cultivation has been generally abandoned. In Bulletin No. 37, of the Idaho Experiment Station, is found the following bearing upon this subject: "The roots of the wild parsnip or water hemlock, which are so virulent in the early spring, have been fed to cows in the late summer and early fall without ill effect. Another member of the same family, the hemlock water parsnip, has a root which is poisonous in the early spring, but harmless after midsummer, while the roots of another plant of the carrot family, poison hemlock, contain no trace of poison during March, April or May, although considerable quantities of the active principle coniin are present in the leaves and stems by May. Later in the season the roots also become dangerous."

2. *Unusual Conditions May Affect the Quantity of Poison in Plants.* In sorghum and Kaffir corn a stunted growth, resulting from arid conditions, is best suited for the development of prussic acid, the most powerful poison known. The poisoning by Johnson grass (a near relative of sorghum), is no doubt due to the same cause, as shown by Crawford and by Jeffries.

The common potato which belongs to the same genus as black nightshade, spreading nightshade, bitter sweet, and other dangerous plants, contains an active alkaloid solanine which develops in large quantities when potatoes become green from exposure to the sun. This is no doubt the cause of the sudden and mysterious death of horses in the vicinity of Greeley that had been turned into potato fields after digging time, many small potatoes having

been left on the surface exposed to the sun. The wilted leaves of the wild cherry are poisonous. In the eastern section of the State a scrubby cherry is found growing along the small streams and arroyas, and some loss in cattle has been reported. Several species of cherry are found growing abundantly along the ravines in the mountains.

3. *Poison Found in Different Parts of Plants.* Another discouraging feature in poisonous plant investigation is that the poison is not always found in the same part of the plant. In the case of wild hellebore, aconite, showy milkweed, thorn apple, and many others, the entire plant is poisonous. In wild parsnips the roots contain most of the poison. In lupines and yellow dock the seeds are dangerous. In potatoes the roots may be harmless and the tops poisonous. In the mountain laurel and wild cherry it is the leaves. In milkweeds the stems are said to be poisonous. In the crowfoot family it is found that the flowers are especially dangerous.

4. *Variations According to Season, Climate, Etc.* There are other serious difficulties to contend with in a systematic investigation of this subject. The danger of certain plants varies according to season, climate, character of soil, etc., from year to year. A dry season is generally favorable for the development of poison in most plants. A plant may be poisonous in one country and harmless in another. Jimson weed is more active in America than in Europe. Some plants become less poisonous by cultivation, such as wild hellebore and aconite. Where the plants contain poison in small quantity the native stock obtain a certain amount of immunity and will feed without harm on a range that will prove disastrous to other animals. The active principle may exist performed in the plant, which is generally the case, or it may be formed by the action of ferments during mastication and digestion.

5. *Some Animals More Susceptible Than Others.* Plants injurious to one species are harmless to others. The horse, mule, and goat eat poison ivy with impunity. Clover and alfalfa may cause a true intoxication, with bloating, under certain conditions, in ruminants; horses pasture upon the green plant without danger. Individuals of the same species show a wide divergence of susceptibility to poisons. As has been well said, "What is one man's meat is another man's poison." Poison ivy produces a violent inflammation of the skin on most persons. Some will escape and are apparently immune at one time, and equally as susceptible at another period of life.

Throughout the vegetable kingdom, from bacteria all the way up to the mighty oak, we find species of plants poisonous under certain conditions, but few of them poisonous under all conditions.

CONDITIONS UNDER WHICH POISONOUS PLANTS ARE EATEN.

Most poisonous plants are bitter and are avoided by animals. When confined to a certain range and not interfered with, they learn to avoid them, but are frequently poisoned while being moved from one locality to another. When an animal is hungry it will eat weeds that it would not otherwise touch. While driving the herd at the time of the roundup or to market they will be seen reaching for the tops of weeds that at other times would not be molested. It is a matter of common observation that the greatest amount of poisoning occurs under these conditions, and the reasons assigned are that animals when driven for some distance become ravenously hungry and have not time to make the same choice of forage plants as when at rest.

The time of greatest danger is during or immediately after a rain or snow storm in the spring months. Alfalfa, whether green or cured, is known to be much more dangerous for cattle and sheep when wet from rain or dew. This seems to be the case with some poisonous plants, especially larkspur. The explanation most commonly proposed for this phenomenon, however, is that when the ground is wet the roots are more readily pulled and eaten, and being much more poisonous, the danger is enhanced.

COMMON SALT AS A PREVENTIVE AND ALKALI AS A SUBSTITUTE.

There seems to be a diversity of opinion among stock raisers as to whether alkali, which is found in abundance in many sections of the State, is a complete substitute for common salt. There are several reputable stockmen on the Western Slope, whose success in business recommends their judgment, that have not salted their cattle for several years, and claim that in withholding the salt they lessen the liability to poisoning, and cattle at least do just as well without it. On the other hand, equally as responsible parties hold that, if salt is not supplied, the animals develop a taste for acrid plants, and thus the danger is increased.

While we have no definite information at hand bearing upon this subject, it would seem that from a physiological standpoint alkali, which is mostly sulfate of soda, sulfate of magnesium, and carbonate of soda, would in a measure take the place of common salt, which is chlorid of sodium, but could not entirely do so. The assumption that lack of salt in some form causes animals to more readily partake of noxious weeds seems entirely reasonable.

The drinking of alkali water is said to cause the death of cattle and sheep, with symptoms much like poisoning from larkspur. The reason for this assumption is due in a large measure to the fact that when animals are poisoned from various weeds they im-

mediately start for water and are found after death lying adjacent to water holes, springs, and accessible streams. In some places the springs of purest water have been fenced in, the owner erroneously believing the water to have poisoned his stock. For the reasons already assigned, the finding of a number of sick or dead animals within a few yards of a spring has frequently caused the owner to suspect his neighbor of having maliciously placed some violent poison in the spring.

PREVENTIVE MEASURES.

Prevention is better than cure. The all important question with the stockmen is how to prevent poisoning. The loss from this source, even though it be small, cuts directly into the profits. Remedies, no matter how efficacious, will only save a small percentage of them. As previously stated, poisoning is more likely to occur while they are being handled, but the aggregate loss will show that the great majority are simply found dead near a water hole adjacent to a patch of larkspur. There is no such thing as complete immunity from poisoning so long as animals are exposed to the weed. If the weed could in some way be eradicated, the problem would be solved. The possibility of displacing poisonous plants with forage plants has led to some experiments along this line by the Montana Experiment Station.* The forage plants tried were the smooth brome grass and the western wheat grass, or "blue joint." It will require several years to determine finally whether this is possible.

In the report of Chesnut and Wilcox, on "The Stock Poisoning Plants of Montana,"** is found the following:

> The short-awned brome grass (Bromus marginatus Nees), a native species, is spreading rapidly in a number of localities in various parts of the State. In some places this grass had already displaced all other native plants and occupied the ground completely. On a cattle ranch near Augusta it has invaded a timothy meadow and entirely killed out the timothy as far as it has spread. This brome grass produces a heavy crop of hay, and a few stockmen, having noticed its good properties, are preparing to save seed for sowing upon other parts of the ranges. Although work along this line extends over only three or four years, the outlook is promising, and it is perhaps not unreasonable to hope that by assisting the distribution of the brome grasses, blue joint, and other aggressive forage plants, the quantity of poisonous plants upon the range may be appreciably diminished.

This, however, were it to succeed, would take many years. Introducing forage plants to supplant others in their natural habitat, on the millions of acres in Colorado ranges is not sufficiently promising to warrant much hope of its consummation in many years to come, if ever.

The feasibility of grubbing out the weeds is worthy of more

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* Bulletins Nos. 15 and 45, Montana Experiment Station.
** Bulletins Nos. 20 and 26, U. S Department of Agriculture.

serious consideration. This I have advised in some cases where the plants were growing in a circumscribed area. It is rather surprising the amount of land that can be cleared by three or four men in a day. In one instance a patch of aconite covering possibly two acres that had been a source of trouble for several years was finally cleaned out in half a day by four men. Of course, where the plants are well distributed over a range of several thousand acres this would be impracticable and all but impossible. There are many instances, however, where the loss in one year would pay for the digging out of every plant. The results of observation and experiment are conclusive that the most dangerous period is in the early spring, and that the plants not only become unpalatable but cease to be dangerous at the flowering period. The most effective means of prevention is for the stockman to become thoroughly familiar with the different species of larkspur, and having located them, pasture the animals on non-infected ranges until the dangerous period is past. The time that they can be placed on larkspur pastures will depend upon the season and the altitude. At high elevations (9,000 to 11,000 feet) it would not be safe before about the 15th of July. West of Fort Collins, at an altitude of 5,500 feet, the stockmen feel quite safe by the 20th of June.

Poisonous Plants.

LARKSPUR. (*Delphinium.*)

There can be no question but that the several species of larkspur growing native in the mountainous districts of Colorado are a greater source of loss to the stockmen than all other weeds combined. While the larkspur is confined to the mountainous regions, it nevertheless holds true that in the aggregate mortality throughout the State from poisonous plants larkspur takes second place only to lòco. We have no statistics at hand whereby we can estimate, with any degree of accuracy, the total lòss, but judging from the reports of other western states and from information received from most every section of the State, it would seem that $40,000 annually is a conservative estimate.

There are four species of larkspur found growing abundantly in the middle and western portion of this State, and one found growing sparingly in the eastern plains section. Other species have been found in isolated places, but have not been especially accused of doing any harm, and their toxicity has not been proved. The four species found in the greatest abundance and named in the order of their importance, are purple larkspur, *Delphinium Nelsonii,* Greene; tall larkspur, *Delphinium elongatum,* (Rydb.); *D. Geyeri,* (Greene), and *D. Barbeyi,* (Huth). These all have the same characteristic flowers, and are found growing in the mountains at altitudes from 5,000 to 11,000 feet. The *D. Penardii* (Huth), has a white flower and may be seen growing adjacent to streams and in the arroyas on the plains as far east as the State line.

In June last this letter of inquiry was addressed to one thousand stockmen in the State, and a fairly liberal response was received.

Dear Sir:

The Experiment Station is conducting an investigation in connection with the U. S. Department of Agriculture, on the range plants of the State, poisonous to stock, and desires the benefit of your experience and observations on the subject. The information obtained will be collated and published and copies will be sent to all who have assisted with information and experience.

The Experiment Station will more particularly take up the question of larkspur and poison plants other than loco.

Please answer as many of the questions as you can, and forward the

blank promptly. Will you please send me samples of any plants you have reason to thing cause trouble, including the flower, if possible.

GEO. H. GLOVER,
Veterinarian.

COLORADO AGRICULTURAL EXPERIMENT STATION
FORT COLLINS, COLO.

LARKSPUR INVESTIGATION.

1. My name is..
P. O. Address..............................
2. I have had experience with....................................on the
Kind of stock
range extending over.......................years; on ranges as follows:
.... in the ....
Give location Foothills
..........................at elevation of............................
3. I have lost.......................................attributed to eating
Kind of stock
larkspur.
4. The loss has been.............per cent annually from................
years' experience.
5. The greatest loss of any one year was....................% which
was in..........................., year.....................
State
6. Of those attacked..........................% died (or better, state how many were attacked and how many died, giving size of herd).
7. What was your remedy for larkspur?..............................
8. The most successful remedy has been..............................
9. State what remedies or methods of treatment did not succeed...........
....
10. Send samples of what you know as larkspur.
11. Do you believe larkspur to kill simply by bloat like alfalfa?...........
....
Reasons ....
12. About what is the altitude of your pasture.........................
13. About what time of year do you experience the greatest loss from larkspur? ....
14. About what kind of livestock has suffered most in your vicinity from this cause? ....
15. Do you believe lack of salt caused them to eat more of this plant than they would otherwise?..
16. Do you believe that rain, snow, etc., aggravate the trouble?...........
....
17. Are animals in poor condition more liable to be attacked than those in good condition?..
18. Are they more liable to be attacked after or during a long drive?
....

Name ....

P. O. ....

The response to this letter of inquiry was, in some respects, disappointing. Of those who were courteous enough to reply, 93 per cent had experienced loss from various poisonous weeds, ranging from one-half of one per cent. to sixty per cent. Seventy-five per cent. of those replying acknowledged that while they had lost animals from some kind of poisoning, yet they were not familiar with larkspur, and expressed a profound ignorance regarding the identity of the plants mentioned. All kinds of harmless weeds were sent to the Station, presuming them to be larkspur, or something equally as dangerous. Four expressed the opinion very emphatically that, while their ranges were infested with larkspur, yet they had suffered no inconvenience and did not expect to so long as the range was not overstocked and plenty of salt was provided .

In answer to question No. 4, the loss ranged from one to five per cent., covering a period of from one to twenty years. In question No. 5 the greatest loss in any one year ranged from one to sixty per cent. The latter being in case of a small herd being driven through the mountains where they came near being exterminated.

Of those attacked the report was that from five to one hundred per cent. died. The remedies suggested were as follows:

Bleeding from the ear-vein or under the tail.

Tapping through the side and allowing the gas to escape.

Turning the head uphill when down. Chasing the poisoned animals, and keeping them on the run.

Slitting the skin in the forehead and pouring in turpentine.

Tobacco, internally, in uncertain quantities.

Bacon, cut into small strips and forced down the throat.

Linseed oil given by drench.

Bleeding and tapping through the side appear to be the universal remedies, and most every answer contained an emphatic statement that animals could be saved by this treatment.

Of the specimens sent, about one-half proved to be larkspur. In answer to question No. 11, forty per cent. believed larkspur to kill by bloat, like alfalfa, and that if they could be tapped soon enough, would all recover. The altitude ranged all the way from 5,000 to 11,000 feet. There was general agreement that the early spring was the most dangerous period. A few had lost cattle and sheep in August, at high elevations. The greatest loss was reported in cattle; next in sheep, and a few reported loss of horses.

In answer to question No. 15, seventy-one per cent. replied in the negative, and the remaining twenty-nine per cent. were sure that lack of salt caused an abnormal appetite for noxious weeds. Practically all agreed that rain and snow, in some way, greatly aggravated the trouble.

In question No. 17, the answers were about equally divided between those who believed that condition of animals had nothing to do with the case, and those who were confident that poor animals were more susceptible and those who thought fat animals more liable. All the answers to No. 18 were in the affirmative except two.

The value of the information gained by this inquiry consists largely in the fact that it reveals in a measure the extent of the loss from these noxious herbs and lays bare before us evidence that the stockmen possess no reliable information regarding them or any other of the poisonous weeds. In one thing, however, they are all agreed, viz.: some poisonous plants are killing the animals from year to year and that it has become a heavy burden. Not knowing anything better, the old fashioned remedies, bleeding, bacon rinds, turpentine, etc., are tried, with indifferent results.

This is not surprising, however, when we come to consider that it is only within the last few years that this subject has received any attention at the hands of investigators, and even now very little reliable information can be had regarding the chemistry, physiology, or satisfactory antidotes for the many deadly plants inhabiting the western ranges.

Description, History, and Habitat. While there are several species of larkspur growing in the State, there are only two, the tall and the purple, found growing in sufficient quantities to warrant a serious consideration. They both have the characteristic spur shaped flower (cockspur), but in other respects differ widely. The tall (*Delphinium elongatum*) grows from one to five feet high, and has a pale blue flower. The leaves are broad and from two to six inches in diameter, and greatly resemble those of the wild geranium. It is found growing along the streams, in moist places, and upon the north side of mountains at an altitude up to 9,000 feet. From the middle of March to the 4th of July, according to altitude, is the dangerous period for this plant. The tall larkspur resembles the aconite (Monkshood), both in its general appearance and toxic effect upon animals. They should not be confused, however, if careful examination of the flower is made, the larkspur having an appendage in appearance like a cock's spur; while the aconite has a flower dark purple in color and with a top resembling a hood, hence the name monkshood. From the reports in other western states, especially Montana, it would seem that the purple larkspur, which is more generally eaten by sheep, is the more disastrous of the two. In this State it is quite the reverse. The tall larkspur is more abundant and the major part of the mortality is among cattle.

The purple larkspur rarely exceeds two feet in height. The

leaves appear on a long stem in the form of a cluster, are finely divided, and in appearance are very different from the large oval leaf of the species previously mentioned. The flowers have the same appearance, save in color, which varies from a deep blue to a dark rich purple. It grows at high altitudes. In the mountains west of the Roaring Fork it was found growing at 11,000 feet, and at lower altitudes had been seen in full bloom on the 20th of April. Very little damage had been reported from this plant after May 1st. As both species of larkspur do their damage before the flowering season, it is of the greatest importance that stockmen familiarize themselves with the appearance of this plant before bloom and assiduously avoid it.

Symptoms of Poisoning. The symptoms of larkspur poisoning are similar to those produced by aconite. The first thing noticed is a stiffness. The back appears to be arched and the legs are carried wide apart. There is usually some frothing at the mouth. The animal stumbles and falls, several times, and trembles violently. The throat is affected and there is persistent swallowing. Breathing is rapid and shallow. In severe cases violent convulsions come on, in one of which the animal finally dies.

Treatment. In cases where the bloating becomes extreme, we have not only the intoxication from the active poison in the plant to contend with, but the excessive accumulation of gas becomes a mechanical condition, which of itself hastens or may even become the principal factor in causing the death of the animal. The practice of tapping through the left side into the rumen for the purpose of allowing the gas to escape in extreme cases is good treatment and has no doubt been the means of saving many an animal. Every stockman should carry a trocar with him while riding the range during the spring months to use for this operation, and not be obliged to use the jack knife. The instrument can be purchased at hardware stores for one dollar or less. The results of using it in the case of bloat in cattle or sheep from any cause are usually perfectly satisfactory, and the animals will not shrink in condition as is usually the case from using a knife.

As previously stated, the most trouble occurs while the animals are being moved from place to place during the spring months. In most cases the man is alone and may have several poisoned at the same time. He is therefore poorly equipped to undertake any complex treatment. His treatment must be simple, effective, and done without delay. The practice of turning them so that they lie with the head up hill is to be commended, as it relieves the pressure on the lungs and heart from the distended bowels. Bleeding is uniformly recommended and practiced by the sheep herders and cow men. It is difficult to see how it can be of any benefit,

and experimentally it has not proved to be so. One gentleman from the Western Slope, who besides being a successful ranchman, was also a graduate physician, explains the beneficial results of bleeding as follows: "It relieves the passive congestion induced by the paralyzing effect of the poison upon the heart."

It is less than fifty years since bleeding was practiced on the lower animals as well as on the human, for every imaginable complaint, and it was considered uniformly efficacious. It has now been discontinued save in rare instances. It is a question whether the animals would not do just as well or better if left entirely alone. The principal effect of larkspur, like aconite, is to depress the heart action; therefore the animal should not be chased or excited.

It would be hard to conceive of a treatment more disastrous, in this case than tobacco. Its action would be much like the poison and disastrous in the extreme. The use of bacon would be absurd. Lard could be given in this case as it is in strychnine poisoning in dogs. Its value consists in mechanically retarding the absorption of the poison. The practice of slitting the forehead and pouring in turpentine is too absurd for serious consideration. This, along with many other absurdities practiced in the name of curative medicine, is to be looked upon as a relic of the superstitions of former days, and should, along with the magic of the witches mess pot, be relegated to the company of the empiricisms of a less enlightened age.

As shown in the account of experiments which follow, we have at least two remedies which possess real antidotal value. These cases of poisoning occur in almost every instance in mountain ranges, far removed from any immediate assistance, and under the worst conditions imaginable. The remedies, whatever they are, must be something that can be carried on horse back and easily and quickly given. As a chemical antidote, potassium permanganate and aluminum sulfate in equal parts in doses of from thirty to fifty grains (five to ten grains for sheep), dissolved in at least a pint of water, is given at one dose, by drench. This remedy, so highly recommended by Chesnut and Wilcox in their Montana investigation, has been repeatedly tried at this Station with most satisfactory results. I believe this remedy to be a practical one for the stockmen. When operating within easy access to water, the powders can be carried ready for solution and given without much delay. With slight inconvenience the solution can be carried ready for use. It is important to see that the powder is completely dissolved. It should then be given at one dose, exciting the animal as little as possible. A number of drugs have been tried experimentally upon sheep and rabbits, with the hope of finding something easy of application that would counteract the depressing effect

of the poison upon the heart and circulation. Most of them were disappointing in the extreme. Stimulants are indicated (alcohol, camphor, ammonia, strychnine, etc.,), and all are more or less beneficial. Glonoin (nitro-glycerine) injected hypodermically, revived the heart's action and abated the alarming symptoms for a time. This, however, did not appear to be a true physiological antidote.

Atropine, given in one half to one grain doses, hypodermically, gave satisfactory, and in some cases, astonishing results. Every stockman should keep on the ranch a hypodermic syringe for inoculating his calves against blackleg, and in this way become familiar with the use of the instrument.. The atropine tablets can be secured at any drug store. A small vial of boiled water may be carried in the vest pocket and the remedy quickly prepared and given to a number of poisoned animals. The dose is one-half to one grain for cattle and horses and one-twentieth of a grain for sheep. I have no hesitancy in strongly recommending potassium permanganate, when used in the way indicated, as a chemical antidote, and the atropine as a physiological antidote. Either drug may be repeated, if necessary, in half an hour. In case these remedies are not at hand, any one of the following stimulants might be tried: Whiskey, in two-ounce doses, for cattle or horses; aromatic spirits of ammonia, two ounces well diluted with water, for cattle and horses. Spirits of camphor, one ounce. Fluid extract of belladonna, two drachms. Nitrous ether, two ounces. For sheep, give one-fourth the amount.

Results of Experiments. In accordance with an agreement entered into with the Department of Agriculture, whereby we were to conduct a co-operative investigation of loco, larkspur, and other poisonous plants, larkspur was gathered at intervals throughout the spring months. The first was gathered on April 26th, when it was about four inches high, and the last on June 12th, at which time the flower was in full bloom and the plants were beginning to dry up. It was dug with roots attached and after drying ten days, was sent in five pound packages to the Bureau of Plant Industry, U. S. Department of Agriculture.

On October 10th Doctor Crawford reported as follows:

"The method used in testing the physiological activity of plants was to weigh accurately five grams of the powdered plants, then extract this over night with twenty c. c. of water, and ten c. c. alcohol added mainly as a preservative. The following day the extraction with water and squeezing was continued until the fluid became colorless. The fluid was then evaporated to dryness in vacuo about 40° C., and the residue made up to 30 c. c. with water. Any number of c. c. would do as well. The alcohol was given off in vacuo.

PLATE I.*

Purple Larkspur, Young Plant.

(*Delphinium bicolor*)

Almost indistinguishable from *D. Nelsonii* of Colorado.

* All Plates, except Plate VIII., are from U. S. Dept. of Agriculture, Chesnut and Wilson Bulletin 26, Div. of Botany.

PLATE II.

Purple Larkspur in Flower.

(*Delphinium bicolor, D. Nelsonii* Greene)

PLATE III.

Tall Larkspur.

Shown as *D. glaucum* in Bull. 26, Div. of Botany, Dept. of Agriculture.
Much the same as *D. elongatum* of Colorado.

PLATE IV.

Death Camas

(*Zygadenus venenosus.*)

The First Batch Collected April 26th, 1905.

1 c. c. injected into a guinea pig (subcutaneously), weight 730 grams. Caused no disturbance.

3 c. c. in guinea pig, no symptoms.

6 c. c. in guinea. Killed.

6 c. c. injected into guinea pig, 285 grams,-killed in 33 minutes.

4 c. c. injected into guinea pig, 352 grams, no symptoms.

Repeated:

5 c. c. killed guinea pig weighing 196 grams. Died in 55 minutes.

4 c. c. injected into guined pig, 299 grams. No symptoms.

Evidently lethal dose for this solution lay between 4 to 5 c. c.

Second Stage, Gathered May 16th, 1905.

Solution corresponding to 4 c. c. of No. 1 caused no symptoms in guinea pig weighing 445 grams, while 5.3 c.c. gilled one of 350 grams, but death was delayed longer than with extract of first stage.

Third Stage, Gathered in June, 1905.

Solution corresponding to 4 c. c. caused no symptoms in guinea pig weighing 376 grams.

5.3 c. c. caused no symptoms in guinea pig weighing 500 grams.

6.6 c. c. caused no symptoms in guinea pig weighing 480 grams.

Evidently lethal dose is much higher and the plant loses much of its activity in development.

This report is very conclusive in proving that the plant contains an active poison, and further in substantiating the claims of experienced observers that the plant loses much of its toxic properties as it approaches the flowering period.

Correspondence with those who have had wide experience with larkspur elicits the fact that animals often eat considerable quantities of the plant without injury. Rabbis lived for days on a on a spare diet of dried purple larkspur, but succumbed readily to the more tempting bait of the green.

It is not the purpose of this bulletin to give a detailed report of laboratory experiments. The results will be briefly summarized at the conclusion of this report. As proof, however, of the statements made regarding the difficulties of securing accurate knowledge of the toxic properties of plants under any and all conditions, the following experiment is interesting as well as instructive:

Seven and one-half grams of dried purple larkspur fed to each of three rabbits on April 20th. No results.

Seven and one-half grams of fresh purple larkspur from same patch fed April 25th to each of three rabbits. Two showed slight uneasiness, and one was bloated a little. One, showing less effect than the others, had eaten but three and one-half grams.

On May 1st a like quantity from the same patch was given to the same rabbits under similar conditions. Results, two died, and the other distressed.

On June 15th, the plants from the same source being in full bloom, but the leaves and stems dry, were fed to rabbits. Al-

though very hungry, they at first refused to eat, but later ate large quantities of it without any ill effects. The experiments with tall larkspur were equally as confusing. The fact that the plants at one period of growth gave negative results was no guaranty that it would not be dangerous at another. The tall larkspur growing luxuriantly on the college campus proved to be very active, physiologically, and furnished the best specimens for producing the physiological effects upon animals. In the experiments with antidotes this domesticated species was found to be very poisonous while in bloom in the middle of August.

Two other species, *D. Barbeyi,* (Huth) and *D. Geyeri* (Greene), found growing sparingly under conditions about the same as the species mentioned, were found to be poisonous. Their relative toxicity, however, was not considered, as they were not found in great abundance.

The several conclusions arrived at with reference to larkspur are as follows: First, at least eighteen species, and several varieties of larkspur, have been found growing in the State. Four growing in the greatest abundance are known to contain an active poison in sufficient quantities to be dangerous to live stock.

Second, death is produced as a result of the presence of an active poison, and not from "bloat," as many stockmen have claimed.

Third, the toxic principle of larkspur has not yet been determined for these species, but is probably delphinine and allied alkaloids present in other species that have not been fully studied.

Fourth, the plant loses its toxic qualities as it approaches the flowering season and finally becomes harmless.

Fifth, two species, because of their abundance, are doing most of the damage, *i. e.,* tall larkspur (*Delphinium elongatum*), and purple larkspur (*Delphinium Nelsonii.*)

Sixth, stockmen generally have little knowledge of the identity, poisonous nature, or satisfactory remedy for larkspur.

Seventh, considering the enormous loss and the fact that larkspur is usually found in circumscribed areas, it would seem feasible, in many localities at least, to undertake its eradication by the grubbing hoe.

Eighth, by avoiding the areas where larkspur abounds during the months of April, May, and June, the loss can be reduced to the minimum.

Ninth, in potassium permanganate and atropia sulphate, respectively, we have a chemical and physiological antidote of real practical value. Stimulants are indicated. Tapping should be done with trocar and canula high up on the left side, after first making slight incision on the skin with a knife. In case of extreme

distention this operation should not be delayed. The value of bleeding is questionable. All measures which tend to depress the animal, such as forcible exercise, tobacco, aconite, etc., are positively harmful. If on sloping ground, the head should be turned up the hill.

DEATH CAMAS. (*Zygadenus Venenosus,* Wats.)

Other names: Wild lobelia, poison camas, poison grass, wild onion, poison sego, mystery grass, wild leek, crow foot.

Description. As will be seen from the accompanying plate, this plant bears a strong resemblance to the wild onion. On account of its bulb it has also been mistaken for the prairie lilly or Indian sego. The bulb of the sego (*Calochortus*) is edible and has furnished food for travelers and generally eaten by the Indians. The wild onion is no doubt a harmless plant. Early in the season death camas looks like grass. It starts a little earlier than grass, and being more succulent and devoid of disagreeable odor or taste, is eaten freely.

Where Found. The plant is found growing in every county in the mountain districts of the State. It is not found in the eastern plains district. Its favorite habitat is along shallow ravines where there is slight seepage. It is often seen, however, growing singly and widely scattered over the high mesas and in shallow depressions commonly found in such places. It is not nearly so abundant nor so widely distributed as larkspur. The camas is much more abundant in the northern part of the State.

While the loss from camas is no doubt small as compared with larkspur, yet for several reasons it is to be looked upon as one of our most dangerous poison weeds. Stock on the range are usually thin in the spring and ravenously hungry for the first green forage that appears. Camas starts a little ahead of grass and is relished by all kinds of range stock. All parts of the plant are extremely poisonous and an animal does not need to eat a large quantity to become fatally poisoned.

In Bulletin No. 37, of the Idaho Experiment Station, is found the following:

"During the past year the tops were found by the Agricultural Department at Washington to contain a poisonous substance, one of the powerful veratrine alkaloids. The bulbs which have been reputed poisonous were not examined. A study of this part of the plant in the Chemical Laboratory of the Idaho Experiment Station showed the presence of at least three alkaloids similar to veratrine, the most important of which appeared to be related to violent poison hellebore, a single milligram, which is only one-fiftieth of a grain, killed a frog in two minutes. The dose of strychnine fatal to the frog is twice that amount, from which some idea of the intensely poisonous nature of the bulbs may be gathered."

Symptoms. The symptoms of poisoning by camas are characteristic. At first they appear to be excited, are unsteady

in their movements, breathe rapidly, stagger, and fall. They appear to be completely paralyzed, but in full possession of their senses. Spasms come on more or less severe according to the amount eaten. In mild cases only a slight stiffness of muscles is noticeable, and this soon disappears. In severe cases of poisoning the animal will lie flat on its side, unable to even raise the head, and death will be delayed for several hours.

Treatment. Chesnut and Wilcox experimented with several antidotes, among the most promising of which was potassium permanganate, given by the mouth, and strychnine, atropine, morphine, and caffeine, hypodermically. In their first report the potassium permanganate is found to be a valuable physiological antidote. The strychnine and atropine had little if any curative value. In further experiments with the active principle, these authors recommended caffeine diuretin.

The directions for giving the potassium permanganate as an antidote will be found in connection with the treatment for poisoning by larkspur.

WATER HEMLOCK. (*Cicuta occidentalis,* Greene.)

Other names: Wyoming water hemlock; cowbane; spotted cowbone; wild parsnip; snake weed; spotted parsley; death of man, etc.

Description. This plant is more commonly spoken of in Colorado as wild parsnip, and is confused with at least three other species, which it greatly resembles on account of the similarity in the umbrellalike expansion of the top.

It is often mistaken for the cultivated parsnip, which it reresembles to some extent. It is not, as many have supposed, the cultivated parsnip gone wild. On the contrary, it is a distinct species and can be distinguished from the garden species by having a white flower. It arises from a bunch of thick tuber like roots, which when cut and pressed will yield a gummy secretion which contains the active poison. The seeds also contain the poison and the foliage early in the season.

Where Found. This plant abounds throughout the entire Rocky Mountain region. It is found in wet or swampy places, along streams, on ditch banks, and often invading the meadows. It is found growing on the plains east of the mountains, more sparingly but under similar conditions.

Symptoms. There is manifest symptoms of great pain; the animal performing much the same as when suffering from colic. This is followed by frenzy and spasms. The breathing is labored. There is frothing at the mouth and finally unconsciousness, the

PLATE V.

Wyoming Water Hemlock

(*Cicuta Occidentalis.*)

PLATE VI.

Lupine

(*Lupinus sericeus.*)

PLATE VII.

Aconite.

(*Aconitum columbianum.*)

PLATE VIII.

Rubber Plant

(*Hymenoxys floribunda.*)

animal dying in violent convulsions. In bad cases of poisoning the animal may die in fifteen minutes. In milder cases it may live for several hours or even days with symptoms less pronounced.

Treatment. The decomposed state of the bowels after death indicate that it is a violent, irritant poison. The remedy most available and effective to counteract this condition is melted lard, or linseed oil, morphine in three grain doses hypodermically, or laudanum in ounce doses to relieve pain are indicated. Chloral hydrate for the same purpose has been recommended, but being itself very irritating, should not be used.

LUPINES. (*Lupinus*)

Other names: Wild pea, wild bean, blue bean.

There are several species of the lupine, but they resemble one another so closely, that a person knowing one will have no difficulty in recognizing the others.

They belong to the pea family the same as the loco weeds, and the two have often been confused. The different species of lupine are found growing extensively in the central and western half of the State, by the road side, in the meadows, and on the mountain side. It is generally eaten throughout the season by all kinds of range animals and is cut extensively for hay. The poison is confined entirely to the seeds. It blooms about June 1st at an altitude of 6,000 feet. Most of the cases of poisoning observed in this State have been in sheep and from eating lupine seeds in hay. When the pods become ripe most of the seeds fall to the ground and the lupine hay may be fed with safety, and it makes a valuable forage crop. It is when the plants are cut a little green or during damp weather and the seeds are retained in the pods in large quantities that trouble occurs.

Symptoms. The symptoms are characteristic. In chronic poisining (*lupinosis*) there is a yellow appearance of the skin and mucous membranes. The urine is highly colored or bloody, depraved appetite, clammy mouth, and general appearance of unthriftiness. This chronic condition has been seen in horses of this State more than in other animals.

Sheep are very fond of the seeds, and where they are accessible, eat them in large quantities, producing the disease in the acute form. In the acute poisoning the animal rushes about in different directions in a state of frenzy. It finally falls in a fit, has violent spasms and dies, usually inside of two hours.

Treatment. In severe cases the violent symptoms come on so rapidly that it seems all but useless to try to save them. In less violent cases of poisoning melted lard, bacon grease, or linseed oil

are usually obtainable and might be given to advantage. Laudanum or morphine to counteract the nervous condition. Potassium permanganate as recommended for poisoning by larkspur promises the best results, but must be given early.

THE RUBBER PLANT. (*Hymenoxys floribunda,* (Gray) Cockerell.

During the summer and fall of 1895 severe losses among sheep were reported from Middle Park on account of this plant. It can not be considered as a truly poisonous plant for as far as we know it contains no active poisonous principle. When eaten in large quantities, however, it forms an indigestible rubbery mass, which obstructs the bowels.

POISONING BY ALKALI.

Because of lack of salt or great thirst, concentrated alkali water is often drank in large quantities, and with fatal results, especially by cattle. The symptoms are bloat, frothing at the mouth, and scours. Animals poisoned from either weeds or alkali are commonly found adjacent to water holes. This fact combined with the similarity of symptoms, makes it difficult or wellnigh impossible for the ordinary observer to determine the cause with certainty. Prevention would consist in salting the stock regularly, and being careful when they are first turned on the range to see that they do not have access to alkali water holes until they have become accustomed to the dilute form of the salts. Treatment would consist in tapping them through the left side with trocar or knife in case they become excessively bloated. Opium, oak bark, tannin, and aromatic sulphuric acid are indicated.

Synopsis of Symptoms and Treatment for Poison Weeds.

CATTLE.

Poisoned on Mountain Ranges.—Bloat, stiffness of legs, continuous swallowing, twitching of muscles, shallow breathing; in April, May, or June,—Larkspur.

Treatment.—Puncturing rumen when bloated; potassium per manganate by drench; atrophine hypodermically; stimulants of whiskey, ammonia, camphor.

Poisoned in a Field of Stunted Growth of Sorghum or Kaffir Corn.—Bellowing, staggering, breath has odor of almonds, suddden death; late in summer,—Prussic acid from eating the corn. No treatment.

Poisoned in Low Ground.—Convulsions, frothing, excessive urination, not many affected at one time; in the early spring and fall,—Wild parsnip.
Treatment.—Melted lard, linseed oil, laudanum, morphine.

Poisoned in Alkali Districts.—Bloat, diarrhoea, frothing, occurring usually in late summer or fall,—Alkali.
Treatment.—Tapping, linseed oil, opium, tannopine, aromatic sulphuric acid.

Poisoned in Open Range.—Emaciation, unsteady gait, involuntary rocking of the head, special sense disturbed, crazy when disturbed,—Loco.
Treatment.—Take them up and feed grain.

In Mountain Ranges.—Stumbling, weaving, stiffness in legs, paralysis, do not lose consciousness, usually a number affected,—Death Camas.
Treatment.—Potassium permanganate and aluminum sulfate dissolved in water.

HORSES.

In the Mountain Ranges.—Violent colic, frenzy, blindness, spasms, bloody urine; in the late summer or winter months, or from feeding lupine hay in seed,—Lupines.
Treatment.—Potassium permanganate, morphine, melted lard, linseed oil.

On the Farm.—Tardy breathing, fever, stupor, costiveness, stumbling, head pushed against wall, or hanging on manger,—Mouldy hay, fodder, potatoes, carrots, etc.
Treatment.—Salicylic acid,, potassium iodide, creolin, internally; purgatives.

In Alkali Districts.—Bloating, scouring, frothing, sweating,weakness; (Alkali).
Treatment.—Tapping, laudanum, linseed oil, aromatic sulphuric acid, stimulants.

In low Pastures and Along Ditch Banks.—Great pain, frothing, frequent urination, spasms; occur in May or June, or in fall and winter when roots of hemlock have been plowed to the surface,—Water Hemlock.
Treatment.—Aloes, morphine in large doses, potassium permanganate, linseed oil.

SHEEP.

Mountain Ranges in August or Lupine Hay in Winter.—Crazy, running in every direction, convulsions, bloody urine,—Lupines.
Treatment.—Same as for cattle.

In Mountain Ranges.—Stiffness, stumbling, paralysis; do not lose consciousness; many affected; occurs in April, May, and June,—Death Camas.
Treatment.—The same as for cattle.

In Mountain Ranges.—Bloating, stiffness of front legs, convulsions, shallow breathing,—Larkspur.
Treatment.—Same as for cattle.

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Insects and Insecticides.

—BY—

C. P. GILLETTE

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INSECTS AND INSECTICIDES

By C. P. Gillette.

The present bulletin is issued to supply the constant call for information in regard to the common insect pests and the remedies that are commonly used for their destruction or prevention. It is really Bulletin 71 revised and somewhat enlarged. The most important additions are the short articles upon two Currant and Gooseberry insects, the Currant and Gooseberry fruit maggot and the Currant and Gooseberry fruit worm. The most important omissions are in cuts of spraying apparatus.

No attempt has been made to include all of the insects injurious to fruits in the State, nor to give the methods of preparing all the insecticides of importance. The station will be glad to receive inquiries concerning any other insect pests that may be troublesome in any manner to residents of Colorado. Always send specimens of the insects and their injuries when possible and give as much information in regard to habits and injuries as you can. Fuller information in regard to any insect mentioned in this bulletin will also be given upon request.

In the second part of this bulletin the insecticides mentioned are numbered, so that in the first part, which treats of injurious insects, the remedies recommended in each case are referred to by number for the sake of brevity.

Many remedies that are rarely of importance and other supposed remedies that are of little or no use, are left out of this bulletin. The attempt is to give the more important remedies for use in this State.

PART I.

INSECTS INJURIOUS TO THE APPLE.

ATTACKING THE FRUIT.

CODLING MOTH.

Flesh-colored larvæ eating into the fruit and causing wormy apples. The first brood of larvæ (worms) begin eating into the fruit when early apples are about an inch in diameter. This brood is not very numerous but it developes into a second brood that comes on late in the summer which is very much more numerous. The moth and its eggs are shown at Plate I., Figs. 3 and 4.

Remedies—The arsenical poisons are, by far, the best remedies we have for this insect. See remedies 3, 4, 5, 6, 7, 8.

The combination of Bordeaux mixture (8) with the arsenites is very popular farther east where fungus diseases are prevalent.

Make the first application as soon as the blossoms have faded and nearly all fallen. Continue the application till every calyx (blossom) is filled with the liquid. Repeat the application in one week. Or, if you were very thorough in the first treatment and if no blossoms have opened since, it will probably be better to follow the plan of Mr. Art. Roberts, of Paonia, and make the second application thirty days after the first, and then make a third application after another thirty days. Whether or not a large number of applications are needed will depend upon the number of wormy apples that appear during July and August. If heavy showers follow a treatment, it is usually well to repeat the application. This is not so necessary if arsenate of lead is used.

Upon the thoroughness of the first and second applications the success will chiefly depend. Just what degree of benefit may be expected from later applications has not been thoroughly determined. *Professor Cordley, of Oregon, seems to have proven that late spraying is very important in that state.

Bandages (36) are also of considerable service if carefully attended to, and if the worms are very numerous. Lights to trap the moths are valueless. Screen cellar windows and doors where fruit is kept.

Plate 2, Fig. 1, shows blossoms from which the petals have fallen and also small apples with their blossoms (calyces) tightly closed so that little or no spray could be forced into them, all upon a single spur of a Duchess tree at one time. The blossoms at (a) are in just the right condition to receive and hold the poison. The two apples should have received the spray a full week earlier. In such a case two early sprays are needed.

HOWARD'S SCALE (*Aspidiotus Howardi*).

This scale is occasionally found upon apples in Colorado. It closely resembles the San Jose scale but seldom causes the red blotch where it rests upon the fruit. Fig. 6 of Plate I. shows this scale upon pear.

For remedies see San Jose scale on a following page.

*Bull. 69; Or. Exp. Station.

ATTACKING THE FOLIAGE.

LEAF-ROLLERS.

The fruit tree leaf-roller (*Archips argyrospila*) is a green larva with a black head and measures about three-fourths of an inch in length when fully grown. The larvæ begin to hatch with the opening of the buds of the apple trees in the spring. They attack at once the tenderest leaves and fold them about themselves for protection. When abundant they may completely defoliate the trees. They disappear during June and do not appear again until the following spring. In the meantime the eggs may be found in little gray patches anywhere upon the bark of trunk or limbs. See Plate I., Fig. 5.

Remedies.—Crush as many as possible of the egg patches during winter and early spring. The best remedy is to spray thoroughly with one of the arsenites 3, 4, 5, 6, 8, as soon as the first leaves are out. Repeat in one week. Make a third application in another week or ten days if it seems necessary.

Protect the toads and insectiverous birds, as both feed freely upon the rollers. The blackbirds are especially destructive to them.

FALL WEB WORM (*Hyphantria cunea*)

This insect is often mistaken for the next species. The webs

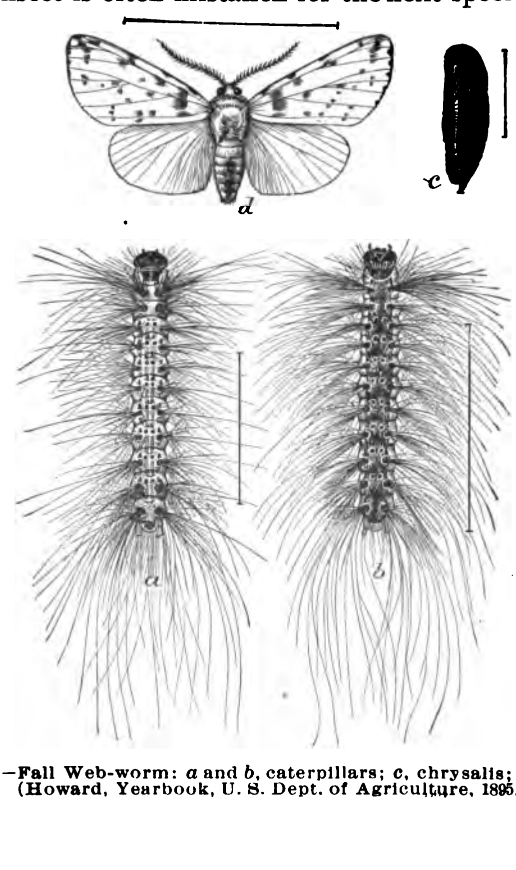

FIG. 1.—Fall Web-worm: *a* and *b*, caterpillars; *c*, chrysalis; *d*, moth. (Howard, Yearbook, U. S. Dept. of Agriculture, 1895.)

are larger and loose or open and the caterpillars stay in them to feed. When the leaves within the tent are devoured, the web is extended so as to take in more foliage. These tents also appear later in the season than those of the following species. They will seldom be noticed before the middle of July. The adult insect is a white moth, sometimes speckled with black. See Fig. 1.

Remedies..—The same as for the following species except that it is not practical to collect the eggs which are deposited upon the leaves.

TENT CATERPILLAR. (*Malacosoma fragilis.*)

This insect also hatches as soon as the leaf buds open, and builds small webs in the forks of the branches. A large number of caterpillars inhabit a web or tent, which is increased as necessity requires. See Plate I., Fig 1.

Remedies.—While the foliage is off, collect the large egg-clusters which are stuck to small limbs. They are covered with a dark, spongy material and are quite readily seen, appearing as galls or swellings of the limbs. If this remedy has been neglected, spray with the arsenical mixtures (3, 4, 5, 6 8). While the tents are small they may bé cut out and burned if on small limbs. If on large limbs they may be burned out with a torch.

APPLE FLEA-BEETLE. (*Haltica* sp.)

The apple flea-beetle is a small metalic-green insect, about an eighth of an inch in length, which jumps or drops from the foliage when disturbed. It is most abundant on young trees or nursery stock or sprouts.

Remedies.—Any of the arsenical mixtures (3 to 8) are effectual in destroying this insect or driving it from the foliage. It can usually be driven from the leaves by the application of dry substances, such as lime, ashes, plaster, etc., (30, 31).

BROWN MITE. (*Bryobia* sp.)

The brown or clover mite is extremely small and its presence is usually first detected by the faded, sickly appearance of the foliage. See Plate III., Fig. 1. The trees appear to need more water. The mites feed upon the leaves but deposit their red eggs upon trunk and limbs. When very abundant, these eggs color the bark red, which is most often noticed during winter.

Remedies —To destroy the eggs while the trees are dormant (during winter) use lime, salt and sulfur mixture (21); kerosene emulsion (14), quadruple strength; whale-oil soap (12), quadruple strength, or crude petroleum (16). To kill the mites during summer use kerosene emulsion or whale-oil soap of ordinary strengths. It is far better to treat the eggs.

APPLE PLANT LOUSE. (*Aphis pomi.*)

A green louse curling the leaves of apple trees, most abundant

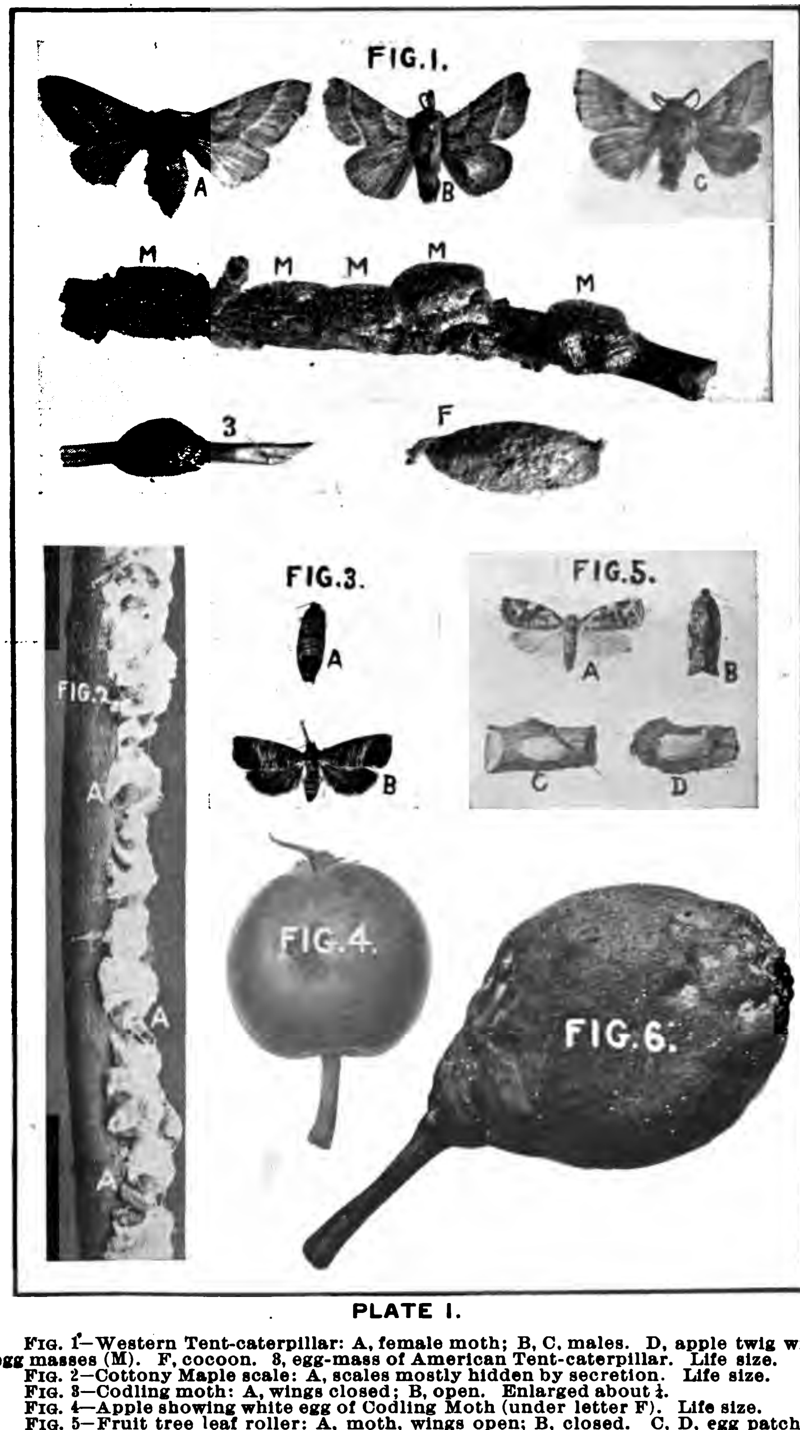

PLATE I.

FIG. 1—Western Tent-caterpillar: A, female moth; B, C, males. D, apple twig with egg masses (M). F, cocoon. 3, egg-mass of American Tent-caterpillar. Life size.
FIG. 2—Cottony Maple scale: A, scales mostly hidden by secretion. Life size.
FIG. 3—Codling moth: A, wings closed; B, open. Enlarged about ½.
FIG. 4—Apple showing white egg of Codling Moth (under letter F). Life size.
FIG. 5—Fruit tree leaf roller: A, moth, wings open; B, closed. C, D, egg patches, hatched. All life size.
FIG. 6—Pear with Howard's Scale. The young appear as minute white specks. Life

FIG. 1—Moths of Peach Borer.

FIG. 2—Peach tree bandaged with paper.

FIG. 3—Peach tree with wire screen. All after Slingerland, (Bull. 176, Cornell Expt. Station.)

PLATE 4.

late in the season, after the middle of July. See eggs on apple twig, Plate 3, Fig. 4. These are minute black objects.

Remedies.—**For the destruction of the eggs, proceed as for the destruction of the eggs of the brown mite above. To destroy the lice, apply kerosene emulsion (14), or whale-oil soap (12), thoroughly and in a manner to bring the liquid in contact with the bodies of the lice.**

SCALE INSECTS.

For the treatment of scale insects it is advisable, in each case, to write to the Experiment Station for specific direction. Specimens of the scale should also be sent. Otherwise, use the treatment recommended for San Jose scale—on page 13.

GRASSHOPPERS.

Several species. Those that fly from tree to tree can probably be managed best by means of arsenical sprays (3 to 8), when safe to use them.

Those that crawl up the trunks into the trees and jump to the ground when disturbed, can quite largely be kept out of the trees by the use of arsenic bran-mash (2) used freely about the border of

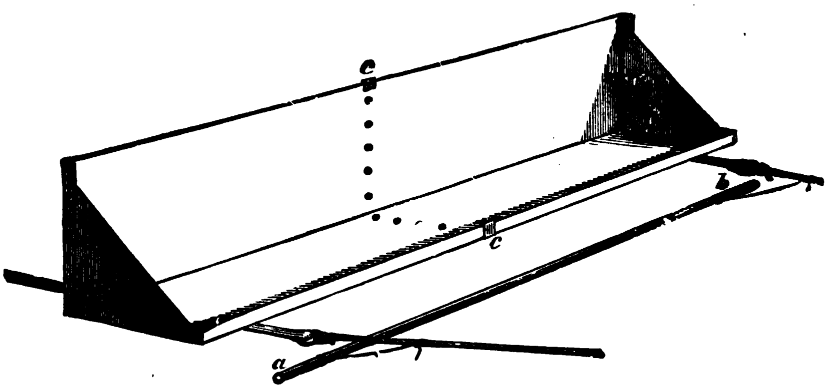

FIG. 2.—Hopper-dozer or Hopper-pan. (After Riley.)

the orchard, and by sticky bands (35) of Raupenleim, tree tanglefoot, printer's ink, or even cotton batting, about the trunks of the trees. If the sticky bands are used they should be spread upon strips of cardboard which have first been wrapped about the trunks.

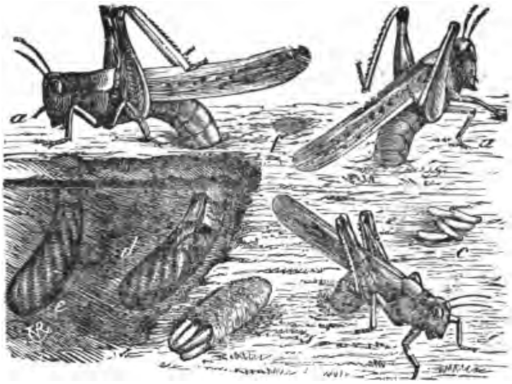

Fig. 3.—Rocky Mountain Locust, laying eggs in the ground; *a*, *a*, females with their abdomens in the ground; *b*, an egg-pod broken open; *c*, scattered eggs; *d*, egg-packet in the ground. (After Riley.)

Grasshoppers that injure orchards usually come from adjoining alfalfa or grass fields. In such cases the free use of the hopper pan (34) in the alfalfa or grass field is the best remedy. One of the hopper-pans is shown at Fig. 2. *At Fig. 3 female grasshoppers are shown in the act of depositing eggs in the ground.

ATTACKING TRUNK AND BRANCHES.

APPLE TWIG-BORER (*Amphicerus bicaudatus*)

A cylindrical, mahogany-colored beetle, about one-third of an inch long, boring holes in twigs of apple, pear, cherry and other trees and grapevines. See Fig. 4.

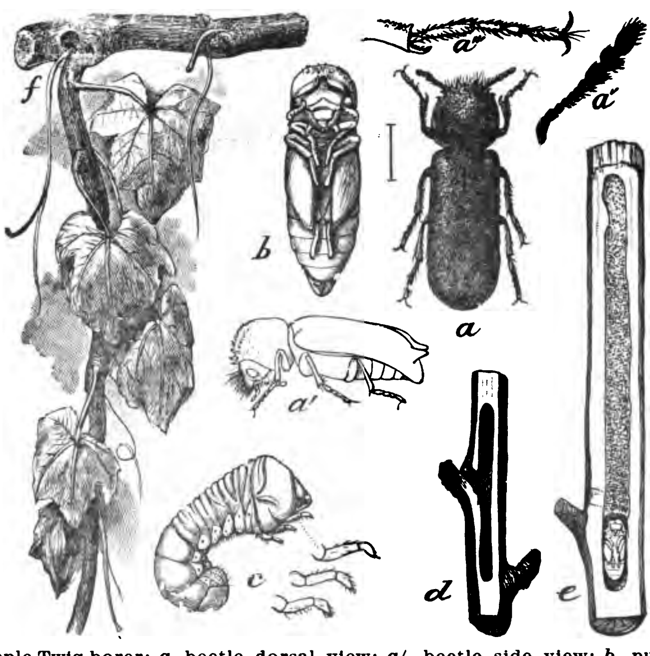

Fig 4.—Apple Twig-borer; *a*, beetle dorsal view; *a'*, beetle side view; *b*, pupa from beneath; *c*, grub, side view; *d*, apple twig showing burrow; *e*, burrow in tamerisk with pupa at bottom; *f*, stem of grape showing burrow. All enlarged except stems showing burrows. (Marlatt, Farmer's Bulletin 70, Div. Ent., U. S. Dept. of Agr.)

Remedy.—Cut out the infested stems and destroy the borers.

*A very successful hopper pan made and used by Mr. P. K. Blinn at Rocky Ford is described and illustrated in bulletin 112 of this station.

BORERS, FLAT-HEADED.

(*Chrysobothris femorata*)

A whitish grub boring beneath the bark of apple and other trees and peculiar in appearance in seeming to have a greatly enlarged flat head. Fig. 5.

Remedies.—Remove with a pocket knife whenever found. Protect the south side of the trunks of the trees from the sun's heat, either by shading or white-washing during late winter and spring.

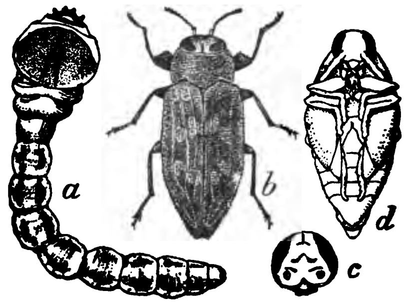

FIG. 5.—Flat-headed Apple-tree Borer; *a* flat-headed larvæ; *b*, the mature beetle; *c*, head of mature beetle; *d*, pupa. All twice natural size. (Chittenden, Circular 32, U. S. Dep. of Agr., Div. of Entomology.)

BUFFALO TREE-HOPPER. (*Ceresa* sp.)

Three-cornered, greenish to brownish insects, about a third of an inch in length. They jump when disturbed and puncture twigs of trees and stems of plants for the deposition of their eggs. From these punctures oval scars result. See Plate 3, Fig. 3.

Remedies.—Infested twigs may be pruned away and burned during winter or spring. Probably clean culture is the best prevention. Keep down all weeds and unnecessary vegetation in and about the orchard.

SAN JOSE SCALE. (*Aspidiotus perniciosus.*)

This insect is very easily overlooked and may be present in sufficient numbers to kill trees before its presence is discovered by the orchardist. They may infest trunk, twig, fruit, or foliage. The scale is nearly circular, about one-sixteenth of an inch in diameter, dark gray in color with a darker spot at the center. Anyone finding such scales upon any tree should send examples at once to the Experiment Station for examination, as there are several species closely resembling each other in outward appearance. As yet this scale is unknown in Colorado orchards. See Plate I., Fig. 6, which shows a closely related species on pear.

Remedies.—Spray with lime and sulfur mixture (21) while the trees are dormant. Or, spray with whale-oil soap (12) in the proportion of two pounds to a gallon of water, or with crude petroleum (16) during winter. If trees are very badly infested, it will often be best to cut and burn them.

PUTNAM'S SCALE. (*Aspidiotus ancylus.*)

Very closely resembling the preceding species. Central spot on the scale reddish. Remedies the same.

HOWARD'S SCALE. (*Aspidiotus howardi.*)

This scale can hardly be distinguished, in external appearance, from the preceding species. It is the only scale that seems to be at all common in Colorado orchards. The central nipple is orange red and the scales are often quite light colored. Its presence should be promptly reported to the Experiment Station. Remedies the same as for San Jose scale above.

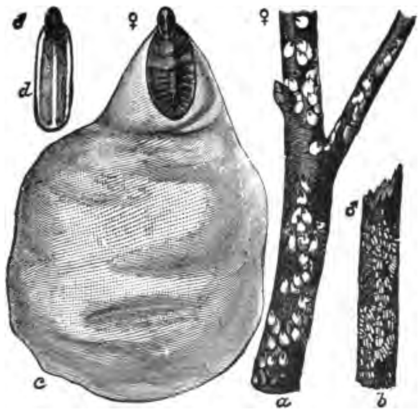

FIG 6.—Scurvy Bark-louse; *a*, twig showing scales of female louse; *b*, twig showing scales of male louse; *c*, scale of female greatly enlarged; *d*, scale of male greatly enlarged. [Howard, Yearbook, U. S. Dep of Agr., 1894.]

SCURVY BARK-LOUSE.

(*Chionaspis furfura.*)

Small white scales resembling scurf or dandruff on the trunk or branches. There are two sizes; the females are larger and oval, and the males are very small and slender. See Fig. 6.

Remedies the same as for the San Jose scale.

WOOLLY APHIS (*Schizoneura lanigera.*)

Small dark lice more or less densely covered with a white flocculent secretion. If the lice are crushed in the hand they leave a red stain. The lice attack chiefly tender bark about wounds or on tender growing shoots.

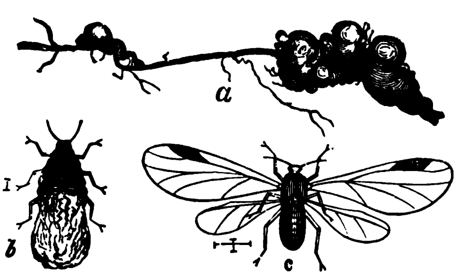

FIG. 7.—Woolly Aphis, root form: *a*, small root showing swellings caused by the lice; *b*, wingless louse showing woolly secretion; *c*, winged louse. (After Saunders.)

Remedies.—Early in the season, when the white patches begin to appear on trunk and branches, paint them over with pure kerosene (16), crude petroleum, or a very strong kerosene emulsion (14), or whale-oil soap (12) mixture. If the lice become abundant late in the season, apply kerosene emulsion or whale-oil soap in ordinary strength but with a great deal of force and a coarse spray in order to wet through the waxy secretion which covers them.

This insect also attacks the roots. See Fig. 7.

OYSTER-SHELL BARK-LOUSE. (*Lepidosaphes ulmi.*)

Scales of the same color as the bark of the tree, about one-eighth of an inch long, curved and small at one end. Very easily overlooked. See Fig 8.

Remedies the same as for the San Jose scale.

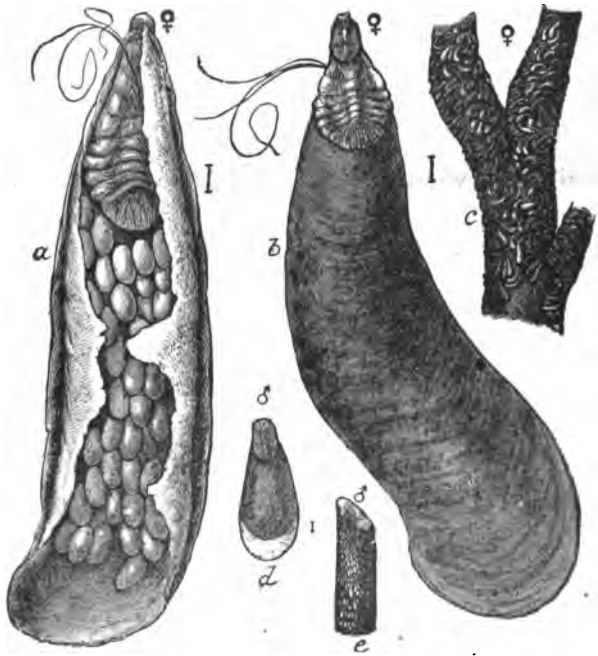

FIG. 8.—Oyster-shell Bark-louse: *a*, female scale from below, showing eggs, greatly enlarged; *b*, the same from above; *c*, female scale on twig, natural size; *d*, male scale enlarged. [Howard, Yearbook, U. S. Dep. of Agr., 1894.]

ATTACKING THE ROOTS.

WOOLLY APHIS. (*Schizoneura lanigera.*)

This insect attacks the roots as well as the trunk and branches. It causes warty excrescences and often the destruction of the greater portion of the smaller roots. (Fig. 7). The description of the louse is the same as for the trunk form mentioned above.

Remedies.—Remove the earth about the crown for a distance of about two feet, put in four to six pounds of tobacco dust (or double this amount of stems) and cover again; then irrigate. If tobacco can not be procured, use kerosene emulsion (14) or whale-oil soap (12) of the ordinary strengths in its place, pouring in a liberal quantity.

INSECTS ATTACKING THE PEAR.

Any of the insects mentioned above as attacking the apple may be found attacking the pear, except the woolly plant-louse, and the same remedies should be employed.

PEAR-TREE SLUG. (*Eriocampoides limacina*)

Slimy dark-colored larvæ with the head end much the larger, somewhat resembling snails, resting upon the upper surface of the leaves, which they skeletonize. See Fig. 9. Two broods each year.

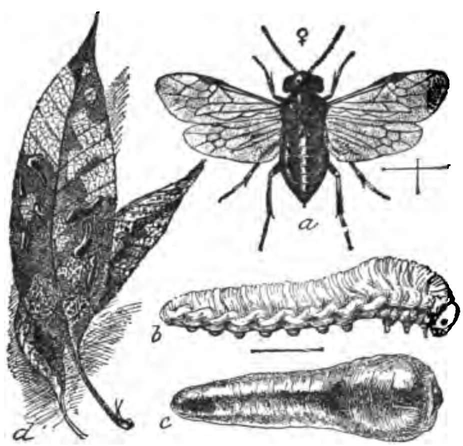

FIG. 9.—Pear-tree Slug: *a*, adult fly; *b*, larva or slug with slimy covering removed; *c*, same as preceding in natural condition; *d*, leaves showing slugs and their injuries. (Marlatt, Circular 26, Second Series, U. S. Dep. of Agr., Div. Entomology.)

Remedies.--Apply white hellebore (9) or any of the arsenical mixtures (3-8), by dusting or by spraying. Freshly slacked lime (20) or wood ashes (29) freeley dusted upon the larvæ will kill most of them.

This is an easy insect to control and should not be allowed to continue its serious injuries to the pear, plum and cherry in this state as it has been doing the past few years.

PEAR LEAF BLISTER (*Phytoptus pyri*).

Small dark spots upon the leaves, sometimes very abundant and involving the greater portion of the surface. The diseased portion is thickened also and at first is green like the rest of the leaf. The leaves often fall prematurely.

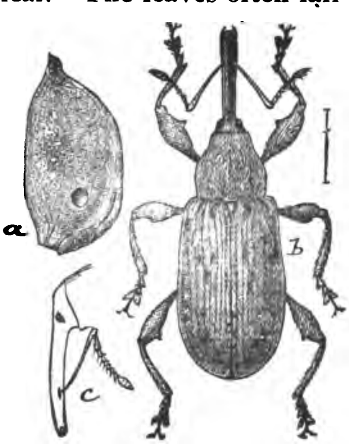

FIG. 10—Plum Gouger: *a*, plum pit showing hole for exit of gouger; *b*, gouger; *c*, side view of head of gouger showing beak and antenna. (Riley & Howard, Insect Life, Vol. II., U. S. Dep. of Agr., Div. of Entomology.)

Remedies.—Spray the trees while dormant with kerosene emulsion (14), treble strength; whale-oil soap (12), one pound to two gallons of water; or with lime and sulfur mixture. Gather and burn as many of the fallen leaves as possible.

HOWARD'S SCALE.

(*Aspidiotus howardi*.)

This scale is too common in Colorado orchards. It is a close relative of the pernicious, or San Jose scale, but so far, has been most common upon plum and pear. Pears, or any fruit affected with scales, should be reported promptly to the Experiment Station. See Plate I., Fig. 6.

Remedies.—The same as for San Jose scale mentioned under apple insects.

INSECTS INJURIOUS TO THE PLUM.

ATTACKING THE FRUIT.

PLUM GOUGER. (*Coccotorus prunicida.*)

A small but rather robust snout-beetle about a quarter of an inch in length; color a leaden gray with head and thorax ocherous yellow; wing covers smooth without prominent humps on them. The beetle eats pin-holes in the growing plums in which it lays its eggs. The larva or grub eats into the pit and feeds upon the kernel, and later eats a hole out through both pit and flesh of the plum just before the plum matures (Fig. 10). The only insect in Colorado injuring the fruit of the plum to any extent.

Remedies.—Jar the trees early every morning, or in the evening, from the time the blossoms are out till very few beetles can be obtained, catching them on a sheet spread beneath. It only takes a very few beetles to do a great amount of harm, as I have found by actual count that a single female may lay as many as 450 eggs.* Gathering and destroying all stung plums during the early part of July would nearly exterminate this insect. Spraying with an arsenical poison (3, 4, 5, 6, 7, 8) once, a few days before the trees blossom, and once or twice after, will give considerable protection. Use the poisons in two-thirds ordinary, or standard strengths. Arsenate of lead (5) is probably the safest to use on the foliage of the plum.

PLUM CURCULIO. (*Conotrachelus nenuphar.*)

This beetle is often confused with the preceding. As yet it has not been reported in Colorado. It is liable any year to appear in our orchards and all should be on the look out for it so as to do all possible to stamp it out or prevent its rapid spread. It is as destructive to the European varieties of plums as the codling moth is to apples. The beetle is brown to blackish in color, is about one-fifth of an inch long, and has two prominent humps and numerous smaller ones upon its wing covers. The beetle makes a crescent shaped cut in the flesh of the fruit where an egg is deposited and the grub does not enter the pit but feeds on the flesh outside of it, causing the fruit to fall.

Remedies.—Jarring and spraying as in case of the preceding species.

Should anyone find what he thinks to be the work of this insect in an orchard, it is hoped he will notify the Experiment Station at once.

ATTACKING THE FOLIAGE.

FRUIT-TREE LEAF-ROLLER. (*Archips argyrospila*)

See under apple insects. Use the poisons only two-thirds as

*Insect Life, III., p. 227.

strong on the plum as on the apple. Arsenate of lead is least likely to injure the foliage.

SLUGS.

Skeletonizing the upper surface of the leaves. See pear-tree slug. Use the same remedies.

BROWN MITE

See under apple insects. Remedies the same.

PLANT LICE.

Two or three species attack the foliage of the plum badly in Colorado. Remedies the same as for apple plant-louse.

Other insects attacking apple foliage may be found on plum, where they are destroyed by the same treatment in either case.

ATTACKING TRUNK AND BRANCHES.

THE PEACH BORER (*Sanninoidea exitiosa.*)

This insect often attacks the plum. For its treatment see peach enemies.

FLAT-HEADED BORER.

See under apple enemies.

SCALE INSECTS.

See under apple enemies. When scales are found it will be well to send specimens to the Experiment Station for identification and advice. Howards's scale and Putnam's scale both occur on plum in the State. They have been injuriously abundant in a few isolated cases only.

INSECTS INJURIOUS TO THE CHERRY.

The insects attacking the cherry in Colorado are the Fruit-tree Leaf-roller, Tent Caterpillar, Fall Web-worm, Brown Mite, Plant Lice, Scale Insects, Grasshoppers, Flat-headed Borer, Twig Borer, Buffalo Tree-hoppers and Pear Slug mentioned above.

INSECTS INJURIOUS TO THE PEACH.

PEACH TWIG-BORER. (*Anarsia lineatella.*)

This is the worst insect enemy of the peach in Colorado at the present time. As soon as the buds begin to open in the spring, a small brownish larva with a black head eats into the buds and

PLATE 2.

FIG. 1—Blossoms from which the petals have fallen and still in good condition to receive the spray. Also apples with calyces closed.

FIG. 2 - Spraying scene in orchard of Mr. Bergher, Palisade, Colo. Photos by the author.

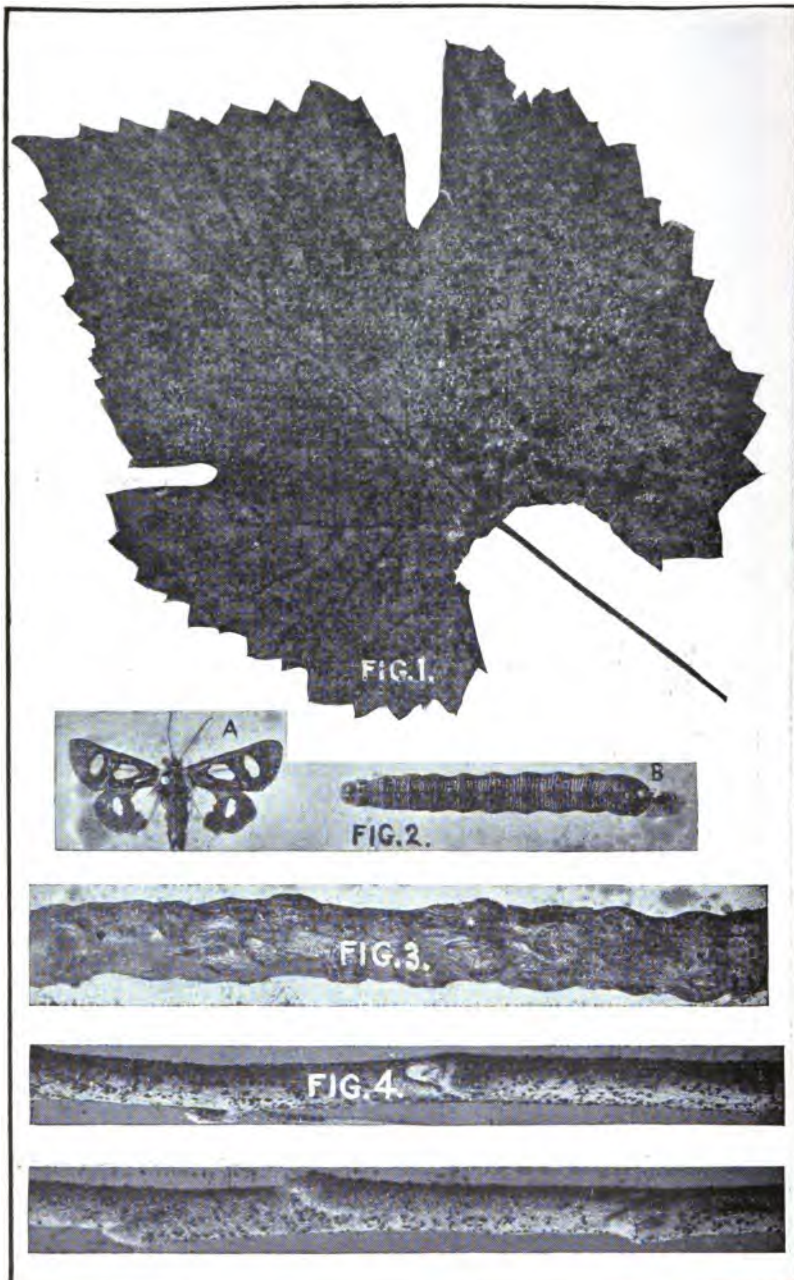

PLATE 3.

FIG. 1—Grape leaf showing bleached appearance due to grape-leaf hopper. *(Typhlocyba comes.)*
FIG. 2—Eight-spotted Forester *(Alypia 8-maculata)*: A, moth; B, larva. Nearly life size.
FIG. 3—Apple twigs injured by Buffalo Tree-hopper *(Ceresa sp.)* Life size.
FIG. 4—Eggs of apple plant-louse on apple twigs. Natural size. Photos by author.

destroys them. When the new shoots start, the borer eats into them causing them to wilt and die. Many of the second brood of this borer eat into the peaches, causing a gummy exudation and ruining them for market. The larvæ that appear in the spring spent their winter in little excavations which they made in the fall in the bark of the trees. See Figs. 11 and 12.

Remedies.—Early in the spring, just before the buds open, spray the trees with lime and sulfur wash (21). Whale-oil soap (12) in the proportion of a pound to two gallons of water. Fish-oil soap (13) diluted once with water, or kerosene emulsion, will doubtless do the work nearly or quite as well as the lime, sulfur and salt. Many of the larvæ may be caught under bandages (33) used as for the codling moth.

Mr. E. P. Taylor has had excellent success with arsenate of lead (5) at Palisade, Colo., this season.

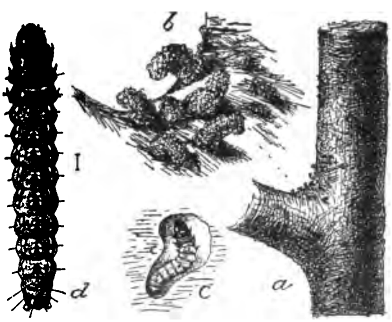

FIG. 11.—Peach Twig-borer: *a*, twig of peach showing little masses of chewed bark above the larval burrows; *b*, the same enlarged; *c*, larva in winter burrow, enlarged; *d*, hibernating larva greatly enlarged. (Marlatt, Bulletin 10, N. S., U. S. Dept. of Agr., Div. of Entomology.)

FIG 12.—Peach Twig and Borer: *a*, young shoot wilting from attack of borer; *b*, adult larva enlarged; *c*, chrysalis enlarged; *d*, tail end of chrysalis showing hooks. (Marlatt, Bulletin 10, N. S., U. S. Dep. of Agr., Div. of Entomology.)

THE PEACH BORER.

A yellowish white borer attaining the length of about one inch, boring beneath the bark of the lower trunk, crown and larger roots. See Plate 4.

Remedies.—Carefully inspect the trees every fall and spring, remove some of the earth next the crown, and search for and remove the borers with the aid of a pocket knife. Their presence is usually indicated by the exhudation of a gummy material upon the bark. Shields of stout paper or wire screen placed about the trunks and left there from the 1st of June till the 1st of August will serve as a means of protection from egg-laying. The paper screen is the better. (See Plate 4, Figs. 2 and 3.)

PLANT LICE.

The plant lice that attack the foliage of the peach may be

treated in the same way as the apple plant-louse mentioned above. The black peach aphis, which does its chief injury to the roots, should be handled in the same manner as the woolly aphis of the apple.

INSECTS INJURIOUS TO THE GRAPE.

THE ACHEMON SPHINX. (*Pholus achemon.*)

Hairless caterpillars devouring the leaves. When small, each caterpillar has a long dorsal spine on the last segment of the body. When nearly grown, the spine is represented by a shining black spot. These larvæ resemble the large tomato "worm."

Remedies.—Any of the arsenical poisons (3, 4, 5, 6, 7, 8) may be used as recommended for apple leaf-rollers. Pyrethrum (24) may also be used as powder or spray, but to kill, it must come in contact with the caterpillars. Hand picking is the best remedy in a small vineyard.

This insect is also bad on Virginia creeper.

THE EIGHT-SPOTTED FORESTER. (*Alypia octomaculata.*)

A dark-colored caterpillar, about one and one-half inches long when fully grown. A close examination will reveal numerous small black and white cross lines and a few red ones to each body segment. See Plate 3, Fig. 2.

Remedies.—The same as for the preceding species.

This insect also infests the Virginia creeper.

STEM BORER.

See apple twig-borer, which also attacks the grape.

TREE CRICKETS. [*Œcanthus* sp.]

The female cricket punctures stems of grape and other plants and in each puncture deposits a long cylindrical egg. The punctures are usually in rows lengthwise of the stem and look like needle thrusts.

Remedies.—Cut out badly infested stems. Keep the vineyard clean of all weeds.

COTTONY SCALE. [*Pulvinaria innumerabilis.*]

This scale, commonly found infesting soft maple, sometimes attacks grapevines. See Plate I., Fig. 2.

Remedies.—Kerosene emulsion made strong, so as to be one-fifth kerosene, thoroughly sprayed during the winter or early spring is very effectual. When the little lice first hatch from the scales, about the last of June, the ordinary sprays of kerosene emulsion (14) or whale-oil soap (12) will destroy them. If the spraying is delayed till a heavy scale has formed over the lice, stronger applications will be required.

GRAPE FLEA BEETLE. (*Graptodera chalybæa)*

A small steel-blue beetle appearing early in the spring and again in midsummer and feeding upon the foliage. The beetles deposit eggs which soon hatch into small dark-colored larvæ which also eat holes in the leaves.

Remedies.—Arsenical poisons (3-8) sprayed or dusted upon the foliage. If unsafe to use poisons, dust freely with Pyrethum (22).

GRAPE-LEAF HOPPERS. (*Typhlocyba* sp.)

Small jumping and flying insects, often called "grape thrips." The insects often fly out from the vine in great numbers when the latter is jarred and return quickly to the under side of the leaves. As a result of the punctures and the extraction of the sap, the leaves lose their dark green color and at first are minutely specked and freckled with white, as shown at Plate 3, Fig. I. Later the leaves shrivel and die. The red spiders, brown mites and thrips cause a similar appearance of the foliage they attack.

Remedies.—Spray forcibly with kerosene emulsion (14), kerosene and water (16), or whale-oil soap (12) very early in the morning while the insects are dormant and drop readily from the leaves. Burn dry leaves, dead grass and other rubbish in the vicinity of the vineyard during winter or early spring, on a cold day.

GRASSHOPPERS.

Remedies.—Use arsenical spray (3 8) where safe. If not safe to spray, use the arsenic-bran mash (2) freely about the borders of the vineyard and about the vines. Make free use of hopper-pans (34) in adjoining fields to reduce the number of hoppers before they reach the vineyard. Plow or thoroughly harrow the ditch banks and the borders of the field late in the fall to destroy as many of the eggs as posible.

INSECTS INJURIOUS TO THE CURRANT.

IMPORTED CURRANT-BORER. [*Sesia tipuliformis.*]

Yellowish white larvæ burrowing in stems, giving rise to wasp-like moths in June. The moths closely resemble those of the peach borer, shown at Plate 4, Fig. 1.

Remedies.—Cut out the infested stems and burn them during winter or early spring. Also keep the old wood well trimmed out of the bushes, and always burn promptly the parts cut out.

CURRANT SAW-FLY. [*Pristiphora grossulariæ.*]

A green larva, about half an inch long when fully grown, feeding upon the leaves of currant and gooseberry bushes. Appearing late in June and again about the last of August. The adult insect is a black four-winged fly about the size of a house-

fly. The eggs are deposited, one in a place, under the epidermis of the leaves.

Remedies.—The best remedy for this pest is white hellebore (9) dusted lightly over the foliage in the evening. If this is carefully done, nearly every larva can be found dead under the bushes next morning. Arsenical sprays (3-8) may be used either dry or in water, as for other leaf-eating insects. These poisons should not be used before the currants are picked. Pyrethrum (22) may be safely used at any time.

THE CURRANT AND GOOSEBERRY FRUIT MAGGOT

(*Epochra canadensis*).

A two-winged fly about the size of an ordinary house fly, but yellowish brown in color and with dusky bands across the wings, appears among the bushes when the berries are about half grown and "stings" the fruit with its sharp ovipositor. In each puncture an egg is deposited just beneath the skin as shown at *e*, and the punctured spot turns dark as shown at *a*, Fig. 14.

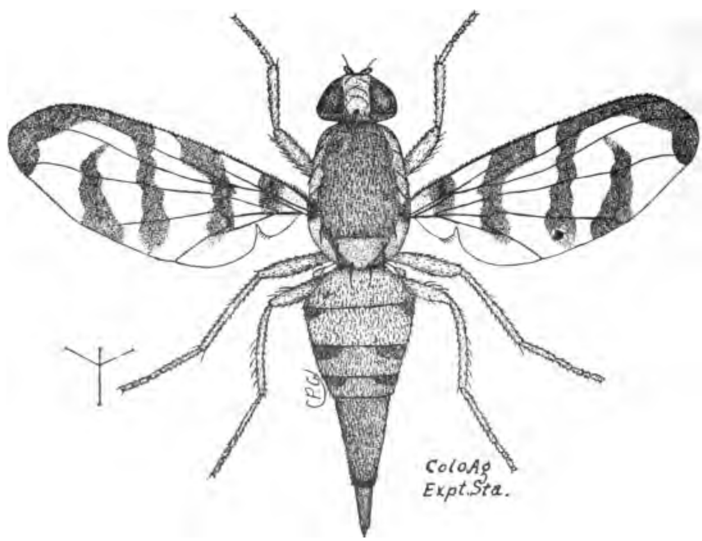

FIG 13.—Adult of Curraan tnd Gooseberry Fruit-maggot.

The eggs soon hatch into little white maggots that eat into the seeds and cause the berries or currants to turn red and drop. When fully grown, the maggot leaves the fruit and works its way beneath the surface of the ground where it stays until the next summer when it comes forth again as a fly to lay eggs upon the next crop of gooseberries and currants.

Remedies.—Insecticides are useless here. If the stung fruit could be gathered and destroyed every day or two, there would be fewer flies

another year. If the surface of the ground is well turned under during the fall or early spring, many of the insects would be prevented from emerging. Thorough cultivation close to the plants throughout the season would do much to keep this insect in check.

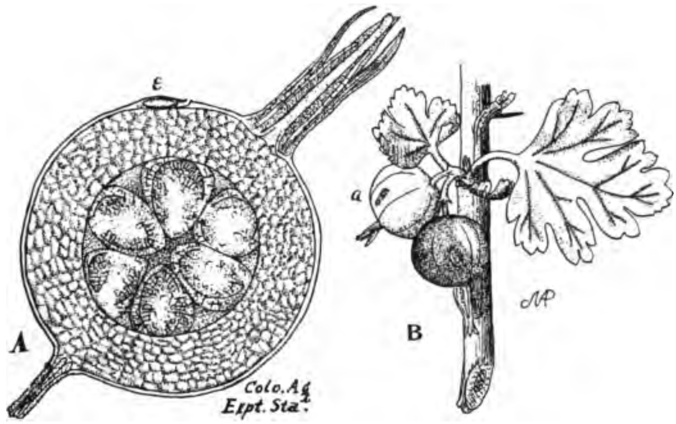

FIG. 14.—Currant and Gooseberry Fruit-maggot: *A*, section through a gooseberry showing egg and puncture at *e*; *B*, two gooseberries on a stem showing egg puncture, or sting, at *a*. Original. Drawings by Miss M. A. Palmer.

This is probably our worst currant and gooseberry pest in Colorado, and as it also attacks the wild currants and gooseberries it is likely always to be rather common in the mountainous districts.

THE CURRANT AND GOOSEBERRY FRUIT WORM

(*Zophodia bella* Hulst.)

A flesh-colored worm, looking very much like the apple worm and about two-thirds of an inch in length when fully grown also attacks the gooseberries and currants in Colorado and often destroys a very large proportion of the fruit. Leaves and fruit are loosely webbed together by the worm which feeds upon the berries. It eats a hole large enough to enter and after devouring the whole interior of one berry it goes to another. The adult insect is a gray moth with rather long narrow wings. The insect and its injuries are shown in Fig. 15.

Remedies.—Poisonous sprays would doubtless kill many of these worms but they would render the currants and gooseberries unsafe to be used as food. If one has a few bushes only for home use, the worms could be nearly all destroyed by pinching the web clusters of fruit between the thumb and finger every day or two until no more appeared. Thorough cultivation would also destroy a large proportion of the chrysalids that spend the winter near the surface of the ground about the bushes.

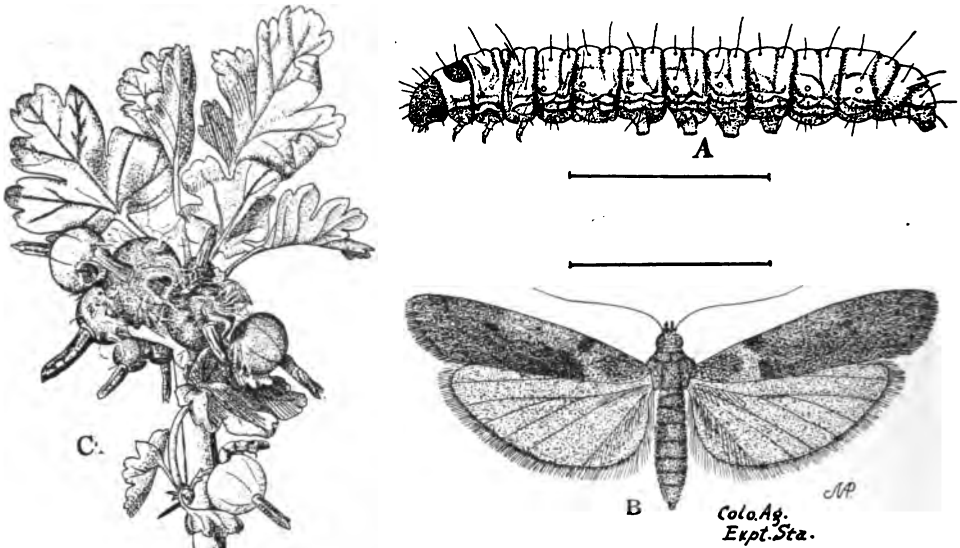

FIG 15.—Currant and Gooseberry Fruit-worm: *A*, worm; *B*, moth; *C*, gooseberries webbed together. Original. Drawings by Miss M. A. Palmer.

INSECTS INJURIOUS TO THE STRAWBERRY.

STRAWBERRY LEAF-ROLLER. [*Ancylis comptana.*]

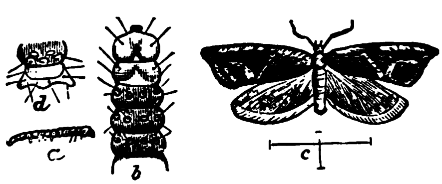

FIG 16.—Strawberry Leaf-roller; *a*, larva, natural size; *b*, head end of larva enlarged; *c*, moth about twice natural size; *d*, tail end of larva enlarged. (After Saunders.)

Small brownish or greenish larva attaining a length of nearly half an inch and having the habit of folding the leaves of the strawberry. In these folds the larva lives and feeds and finally changes to a small rust-colored moth with white marking on the wings. See Figs. 16, 17.

Remedies.—When the fruit has been gathered, scatter straw over the vines and burn it. Arsenical sprays (3-8) may be used, but the worms are so protected in the folded leaves that it is difficult to get a poisonous dose to them. The vines will put up a good growth of tops after the burning, if it is not done too late.

FIG. 17.—Strawberry leaves showing their appearance after being folded. (After Weed.)

STRAWBERRY CROWN BORER.

[*Tyloderma fragariæ.*]

A small yellowish white grub boring into the crown of the plant during summer.

Remedies.—Burning as for the preceding species will destroy a large proportion of the borers. Do not allow the plants to become very old, but plow each year or once in two years as soon as the berries are picked, and start a new bed at some distance from the old one. Poisons are of doubtful value.

PART II.

INSECTICIDES.

THEIR PREPARATION AND USE.

In order to be able to apply insecticides intelligently and with success, it is important to understand something of the habits of the particular insects to be destroyed and also of the nature of the remedies to be used. Many insects, like grasshoppers and the potato beetle, devour the surface tissue of plants, while others, like plant-lice, squash-bugs, and scale insects insert sharp tubular beaks into the tissues of plants and suck the sap from beneath the surface. Insects of the first class may nearly always be destroyed by means of food-poisons, such as arsenic, Paris green, hellebore, etc., while those of the latter class are unaffected by food poisons and have to be killed by substances that come in contact with the surface of their bodies, or in some other manner. It is not necessary to be a skilled entomologist in order to determine which class of insects is doing injury to the plants in question. If the leaves are ragged or eaten full of holes, it is practically certain that the injury is being done by an insect with biting-mouth parts. If the leaves simply wilt and dry up without having the tissue eaten away, the insect doing the injury is of the second type mentioned. The most common remedies for this class of insects are kerosene emulsion, whale-oil soap, crude petroleum, and lime salt and sulfur washes.

In many cases it is impossible to get an insecticide upon the insect that it is desired to kill, or upon its food, and then other means have to be used to prevent the injuries. Borers, underground feeders upon roots, and weevils living in seeds, are examples of such insects.

In the pages that follow I shall not attempt to treat of all the methods used to destroy insects or avoid their injuries, but the more important ones only.

SUBSTANCES THAT KILL BY BEING EATEN.

Nearly all the food-poisons have for their active principle arsenious acid, or white arsenic (As_2O_3). White hellebore and borax, are about the only exceptions.

1. WHITE ARSENIC.

While this is the cheapest of the arsenical poisons, it is used but little, except for the purpose of making arsenical compounds

with other substances: Because some states have passed laws requiring a high percentage of arsenic in Paris green, arsenic has been used as an adulterant of this poison, and thereby working an injury to the purchaser if not a benefit to the manufacturer of it, because arsenic is much cheaper than Paris green; and when it is mixed with the latter, it greatly increases its liability to burn foliage. The reason that white arsenic burns foliage badly is it dissolves in water and, when in solution, it penetrates the leaves and kills the living tissue. Arsenical mixtures must *never be in solution, but only in suspension*, in the water that is used to distribute them upon foliage.

2. ARSENIC BRAN-MASH.

Prepared by mixing one pound of arsenic and 20 to 50 pounds of bran together with just water enough to thoroughly moisten the mass. Some prefer to add a pound of sugar to the above in order to cause the particles of bran to adhere to each other, so that it may be distributed in little balls pressed together with the hands or with a paddle. This poisoned bran is used for the destruction of grasshoppers in orchards and vineyards where it is not possible to use a hopper-pan. Many prefer to sow the moistened bran and arsenic broadcast where the grasshoppers are numerous. Paris green may be substituted for the arsenic.

3. PARIS GREEN.

This poison in a pure state is said to be composed of three substances—arsenious acid, acetic acid, and copper oxide—united in a chemical combination. The percentage of arsenic may vary considerably, as these substances do not always combine in exactly the same proportions. The range is nearly always between 55 and 60 per cent. arsenic, with an average of about 58 per cent. *Mr. J. K. Haywood, one of the chemists in the Department of Agriculture at Washington, D. C., says that the chemical composition of Paris green should be:

	Per cent.
Arsenious acid	58.65
Copper oxide	31.29
Acetic acid	10.06

Pure Paris green is one of the very best of the arsenical compounds for the destruction of insects, but this poison is often found greatly adulterated upon the market. If adulteration is suspected, or if the poison is being purchased in any considerable quantity, it is advisable to test its purity in some way. Pure Paris

*Farmer's Bull. No. 146, U. S. Dept. of Agr.

green is entirely soluble in ammonia, giving a clear blue liquid. If any particles can be seen floating through the liquid, or settling to the bottom, the article is not pure. If the amonia dissolves all, there can be little doubt that it is pure. This is a test that anyone can make. The particles of Paris green are entirely bright green in color and globular in form, and the presence of an adulterant can be most easily detected under a microscope of moderate power. Prof. Woodworth of the University of California explains another method by which impurities can usually be detected in Paris green. It is by placing a small amount of the poison on a clean piece of glass and then slanting the glass and jarring it so as to cause the powder to slide to the lower side. If this is done carefully the adulterants, which are not green in color, will fall behind and can be detected with the unaided eye.

Where there are several persons in the same neighborhood wanting this poison, it is best for all to order together and then send a sample to a chemist for analysis. If a good number unite in this way the Station chemist, most likely, would be willing to make the test free.

Application of Paris Green to Plants.—This poison is usually applied in a watery spray, and the most common strength is:

Paris green	1 pound
Water	160 gallons
Lump lime (freshly slacked)	2 pounds

On very sensitive foliage, like that of the peach, apricot, nectarine and bean, it would be safer to use 200 gallons of water to a pound of poison. A pound to 100 gallons is quite safe for applications upon apple, cherry, cabbage, beets, potatoes and most other trees and plants in the dry atmosphere of Colorado. The poison always should be placed in a small quantity of water first and thoroughly stirred in and then poured into the full amount of water to be used.

The chief objection to the use of pure Paris green as an insecticide is its high specific gravity, which causes it to settle rapidly in water. Pumps used to apply this poison always should have some means of keeping the water well stirred.

Dry applications may be made in various ways. Sometimes the poison is used pure, in which case the lightest possible dusting is made over the plants. It is usually better to dilute the poison with about twenty times its own weight of flour, plaster or lime when a more liberal dusting may be made. This method is more

economical of the poison and enables one better to tell when all parts of the plant have been treated. A good proportion is:

Paris green	1 pound
Common flour	25 pounds

The advantages of flour over lime or plaster are, it helps better to stick the poison to the leaves and is not distasteful to insects. Particles of poison imbedded in a mass of plaster or lime would probably be avoided by most insects. Filling the blossom ends of apples with lime mixed with poison may drive the worms to eat their way into the apples where they will escape the poison entirely.

The methods of applying dry poisons are chiefly two. If low plants, like cabbages and tomatoes, are to be treated, and the area to be covered is not too great, a very satisfactory method is to make a small sack—about ten inches long by five inches in diameter—of strong cheesecloth or other light muslin, fill half full with the mixture of poison and flour and then shake or jolt the sack over the plants.

Where large areas are to be treated, or where it is necessary to make the application to trees or high bushes, some kind of dust gun or bellows is an advantage. Powder guns of different kinds are upon the market and some of them are being extensively advertised at this time. These instruments have a place to fill, but I do not believe they can take the place of the watery spray for large trees, and particularly for the application of poisons for the destruction of the codling moth.

4. SCHEELE'S GREEN (GREEN ARSENOID).

Scheele's green, also sold as "green arsenoid," differs very little from Paris green in chemical composition, except in lacking the acetic acid. It is considered as effectual as an insect destroyer, and has a great advantage over Paris green in being much more finely divided, so that it remains in suspension in water for a much longer time. It is also cheaper in price. Dr. Marlatt, of the Division of Entomology, says it should replace Paris green as an insecticide.

Apply either wet or dry, as recommended for Paris green.

5. ARSENATE OF LEAD.

This compound contains only about 20 to 25 per cent. of arsenic acid, but has some important advantages over the other arsenical compounds. It is so completely insoluble in water that it may be used in almost any strength without injuring foliage and consequently is least likely to injure plants that are most sensitive to arsenical poisons. When suspended in water this poison is so finely

divided that it settles slowly, and consequently can be more evenly distributed than most arsenical mixtures. Its third point of superiority is in its adhesive qualities when applied to foliage. Applications made to foliage in the latter part of May at this Station could plainly be seen upon the leaves the first of September. The disadvantage of the poison is its not being quite so quick to kill the insects that eat it as are the other arsenites, consequently it is necessary to use it in stronger mixtures.

To prepare arsenate of lead, dissolve in water arsenate of soda and acetate of lead (white sugar of lead) in the portion of three pounds of the former to seven pounds of the latter. Then use not less than five or six pounds of the combined chemicals to each hundred gallons of water. Three or four times this strength will do no harm to foliage. If the poison is purchased ready made, use:

Arsenate of lead	4 to 6 pounds
Water	100 gallons

6. ARSENITE OF LIME.

White arsenic and lime may be made to combine, forming an arsenite of lime that is practically insoluable in water. The poison may be prepared in either of two ways. What is known as the Kedzie formula is as follows:

> "Boil two pounds of white arsenic and eight pounds of salsoda for fifteen minutes in two gallons of water. Put into a jug and label *'poison'* and lock it up. When ready to spray, slack two pounds of lime and stir it into forty gallons of water, adding a pint of the mixture from the jug.

The other method is to boil together arsenic, lime and water for a full half hour in the following proportions:

White arsenic	1 pound
Lump lime	4 pounds
Water	4 gallons

Then dilute to 200 gallons of water before applying to foliage.

These preparations have become very popular in the past few years and deservedly so. White arsenic is cheap and consequently is in very little danger of adulteration, so that one is almost certain of the strength of his mixture when using this poison. Care must be taken, however, to *use fresh unslacked lime of good quality.*

Before being diluted for use, the mixture should be passed through a coarse cloth or seive, to take out the lumps that would otherwise clog the spraying nozzle.

7. LONDON PURPLE.

London purple is a by-product in the manufacture of aniline dyes and has for its active principle arsenite of lime. It also contains some free arsenic, lime, coloring matter and other impurities. The amount of arsenic present is subject to considerable variation, but will usually range between 40 and 55 per cent. As there is often considerable soluble arsenic present, it is always best to use a pound or two of freshly slacked lime with every pound of the poison if used in water.

This poison is finely divided and remains in suspension in water much longer than Paris green does and it usually sells at about two thirds the price of that poison. It seems to be going into disfavor because of its variable composition and the danger of its burning foliage. It is also considered somewhat less effectual in killing insects than is Paris green or Scheele's green. It should compare favorably, however, with the prepared arsenite of lime in its power to kill insects, and there is little danger that it will be adulterated, as it is a waste product.

Apply either wet or dry in the manner and in the same proportions as are previously recommended for Paris green; being sure to add a pound or two of freshly slaked lime for each pound of poison if used as a spray.

8. BORDEAUX MIXTURE AND THE ARSENITES.

Bordeaux mixture is a fungicide and is the substance most often used for the destruction of fungous diseases that attack the surface of the plants. It has been found to be of value for use against flea-beetles, and the writer also demonstrated its value a number of years ago as a medium in which to spray Paris green or London purple. These poisons can be used very strong in this mixture without injury to foliage and they do not in the least lessen its effect as a fungicide. Such a mixture will destroy both insects and fungi with one application.

Bordeaux mixture may be prepared as follows: Take of

Copper sulfate	4 pounds.
Quicklime	4 pounds.
Water	45 gallons.

Dissolve the copper sulfate in a gallon of hot water, slake the lime in another gallon of water, and then add the milk of lime slowly to the copper sulfate solution while the latter is being constantly stirred. Then add 43 gallons of water.

If insects are to be killed at the same time, add to the above quantity of Bordeaux mixture one-third pound of London purple, Paris green or Scheele's green, or two pounds of arsenate of lead.

9. WHITE HELLEBORE.

Hellebore, as obtained from drug stores, is a light, yellowish-brown powder. It is a vegetable poison and is obtained by pulverizing the roots of an European plant *Veratrum album.* It is not as poisonous as the arsenites and consequently it is not as effective in the destruction of most insects, but it has its special uses. Slugs, which are the young of saw-flies, are particularly susceptible to its effects. The poisonous property is an alkaloid and it loses it virtue after being exposed to the air for a few days. For this reason it can not be used where it is likely to remain long before being eaten, and it must be kept in tight receptacles and must not be kept too long before using. It is often useful for the destruction of insects upon plants containing fruit that will soon be used for food.

Dry applications are easily made upon low plants by making a small cheesecloth sack, through which the dust may be sifted lightly over the foliage. The best tim e to apply is in the evening

In the wet way use:

White hellebore	1 ounce.
Water	3 gallons.

Apply as a spray in the evening.

10. BORAX.

Used chiefly for the destruction of cockroaches. Spread the powdered borax upon bread, sweet potato or banana peelings, or mix with sweetened chocolate, and place the bait where the cockroaches can get at it.

SUBSTANCES THAT KILL BY EXTERNAL CONTACT.

Substances in this group are chiefly used against insects that take liquid food from beneath the surface of the plant by means of a tubular rostrum or beak, but they may be used against many other soft-bodied insects with success. Insects having a hard outer crust to their bodies resist these substances and are not easily killed by them. If insects are covered with a powdery or cottony material, the insecticide will have to be applied with considerable force to cause it to penetrate to the body. Applications must always be thorough, because only those insects will be killed that have the substances thrown upon them.

11. SOAP.

The ordinary soft soaps and laundry soaps have long been used for the purpose of killing vermin on plants and animals, and

they have considerable insecticidal value, particularly for the destruction of very tender insects, like plant lice. The soaps that are specially useful for the destruction of insects, are sold as whale-oil soap, fish-oil soap, or tree-soaps. Whatever the name, the oil is usually fish-oil.

12. WHALE-OIL OR TREE-SOAP.

For ordinary plant lice one pound of the soap to eight or ten gallons of water is sufficient if the application is thorough. Double this strength will not injure most plants and is often required to destroy more resistent insects. For scale lice, like the San Jose scale for example, it is used as strong as a pound, or even two pounds, to a gallon of water. These strongest applications can only be used in the winter or early spring when the trees are dormant. The soap is more effectual if applied when quite hot.

13. FISH-OIL SOAP (HOME-MADE).

Lodeman in his "Spraying of Plants" gives the following formula for the preparation of fish-oil soap:

Potash lye	1 pound
Fish-oil	3 pints
Soft water	3 gallons

Dissolve the lye in boiling water and then add the oil and boil for two hours longer. When using dissolve a pound of this soap in from six to ten gallons of water. Use for the same purposes as whale-oil soap, and in the same strengths.

14 KEROSENE EMULSION.

This preparation is probably the best general purpose insecticide for the destruction of insects by external contact. The materials composing it are always at hand and it is not difficult to prepare after one has had a little experience. Soft water should be used, if possible. If hard water is used it may be necessary to "break" it first by adding washing soda or potash lye.

To make the emulsion use the ingredients in the following proportions:

Soap	1 pound
Kerosene	2 gallons
Water	27 gallons

Prepare by dissolving the soap in a gallon of water, then, while the soapy water is boiling hot, remove from the fire and immediately add two gallons of kerosene and agitate briskly for a few minutes. If a large amount is being made, use a force pump and forcibly pump the mixture back into the receptacle that con-

tains it until all is a frothy, creamy mass. If such a mixture is not obtained in a very few minutes, put the whole over the fire again until it boils and then repeat the pumping, and the emulsion will almost surely form. When put back for reheating, *watch every moment to see that it does not boil over and take fire*. This work should be done out of doors. After the emulsion is made, add the remaining 27 gallons of water and all is ready for use.

Small quantities may be emulsified with a rotary egg-beater.

Whale-oil soap, or any cheap soap, may be used.

Clean dishes and clean water should be used. Every particle of dirt in the emulsion serves as a center of attraction about which the oil droplets will collect and then rise to the top to form a film of oil on the surface.

The strength above given is suitable for most insects. Most plant lice may be killed with an emulsion of half the above strength.

15. KEROSENE-MILK EMULSION.

Kerosene will emulsify with milk, also, and when small quantities are wanted it is often less trouble to use the milk than to prepare the soapy water. These proportions are:

Milk (sour)	1 gallon
Kerosene	2 gallons

Dilute with water as in the preceding formula. If sweet milk is used, add a little vinegar. Otherwise it may be impossible to form a stable emulsion.

16. KEROSENE AND CRUDE PETROLEUM.

These oils are used pure, and also diluted with water, for the destruction of scale and other insects. Experiments in the Eastern States seem to indicate that the safest time to apply is early in the spring, just before the buds swell, and on a bright, windy day when the oil will evaporate rapidly. It seems that when applied in moderation, in the proportion of 40 parts of the oil to 60 of water, these substances will seldom injure apple, cherry or pear trees, but can hardly be applied to tenderer trees, such as peach and plum, without further dilution.

When diluted with water in the form of a spray they may be used upon foliage of most plants, without injury, in the proportion of one of the oil to five or six of water. Most plant lice are killed in mixtures as weak as one of oil to fifteen or twenty of water.

Pumps are now made for the purpose of mixing the oil and water in the form of a spray, and so do away with the need of preparing an emulsion. The one who has the insecticides to apply

must decide whether or not he will go to the extra trouble of making the emulsion or whether he will go to the extra expense of purchasing a special and somewhat more costly pump that may not work very satisfactorily at all times.

17. GASOLINE.

This oil is also destructive to insect life. Its chief use is for the destruction of bed-bugs. It is applied pure by means of an oil-can or hand atomizer. To be effectual the bugs must be thoroughly treated with it. As it is inflamable, care must be taken not to bring fire near until the apartments where it is used are well aired.

18. TURPENTINE.

Turpentine is used for the same purposes as gasoline and the same precaution applies.

19. LYE AND WASHING SODA.

These substances are in considerable popular favor for the destruction of insects, but the writer's experience with them has not been encouraging. In the proportion of a pound to three gallons of water they may be used upon the trunks of trees and will kill soft-bodied insects that might be wet by them. To be used upon foliage they should be diluted to a pound to forty gallons of water, and in this strength they will hardly destroy the tenderest of insects. Kerosene emulsion or whale-oil soap are much more effectual insecticides.

20. LIME.

Lime, either wet or dry, may be used freely upon foliage without fear of injury. It is of very little value as an insecticide. When freshly slaked and freely dusted upon the slugs that infest pear, cherry and plum trees, it causes them to drop off and most of these perish. Experiments at this Station have not been wholly successful in killing slugs this way. As a coating upon the bodies of fruit trees it undoubtedly does much to prevent sun-scald late in winter and early in spring. The addition of a liberal amount of skim-milk or salt, or both, to the preparation will greatly increase its adhesive qualities. The following formula is printed in the 1899 report of the Canada Experimental Farm:

Skim-milk	6 gallons.
Water	30 gallons.
Lime	60 pounds.
Salt	10 pounds.

21. LIME, SALT AND SULFUR WASH.

This wash, when properly made, is one of the most effectual

applications for the destruction of scale insects and eggs of the brown mite, particularly in dry climates, like that of Colorado. It should be used only in the winter or spring, while the trees are dormant. The ingredients may be in the following proportions:

Lump lime (good)	20 pounds.
Sulfur	15 pounds.
Salt	10 pounds.
Water	50 gallons.

Slake the lime, preferably with hot water, in an iron kettle or a barrel, and while slaking, slowly add the sulfur and stir it in. Then boil over a good fire or by means of a jet of steam in about one half the required amount of water (25 gallons) for an hour or two, or until a dark red color is obtained. Then add the salt and boil for 15 minutes longer, strain, dilute to 50 gallons and apply while hot. Many are leaving out the salt and they seem to have just as good results.

22. PYRETHRUM, BUHACH, OR PERSIAN INSECT POWDER.

This substance is a vegetable powder and is obtained by pulverizing the dried blossoms of plants of the genus Pyrethrum. It may be obtained at almost any drug store, and is peculiar in its power to kill insects while it is not poisonous to the higher animals. It may be used either wet or dry. If applied in water, use in the proportion of:

Pyrethrum	1 ounce.
Water	3 gallons.

If applied dry, use pure and make a very light application, or dilute with flour and apply more freely.

If thoroughly disseminated in the air of a room it will soon bring to the floor all the flies and mosquitoes therein. A good way to rid a room of flies is to make a thorough dusting of the powder through the room and then close the room tightly for the night. Then in the morning sweep up the flies and burn them. If they are not destroyed in this way after being stupefied, many will finally overcome the action of the powder and live.

23. TOBACCO.

Tobacco has long been used in one way or another for the destruction of insects. Its chief use seems to be for the destruction of lice. When slowly burnt the smoke may be utilized for the destruction of lice on plants in greenhouses or window gardens. In the form of a fine dust it is often effectual in ridding plants of flea-beetles, and in the form of dust or stems is probably the best remedy we have for woolly aphis on the roots of apple trees.

A decoction made by boiling tobocco dust or stems in water in

the proportion of a pound to three or four gallons, is destructive to plant lice (Aphidæ) and to lice upon cattle. Tobacco, very finely powdered, in the form of snuff, may also be used dry against the same insects. It is best to first spray the insects with water.

24. SULFUR.

Everyone knows of the use of sulfur fumes for the destruction of animal life. Sulfur is specially destructive to "red spiders" and "brown mites," and may be applied as flowers of sulfur, dry, through a blow-gun of some sort, or mixed in soapy water or soap solutions in the proportion of an ounce to a gallon of the liquid and applied as a spray. The liquid must be kept thoroughly stirred, as the sulfur settles quickly.

25. HOT WATER.

Water heated to 130 to 140 degrees Far. kills very quickly any insect that is put into it, but is harmless to plants unless they are kept submerged for a long time. Lice, especially those on roots, may often be killed conveniently with hot water.

SUBSTANCES THAT KILL BY BEING INHALED.

There are two insecticides of this sort that are of special importance. As both are destructive to vegetable life also, care must be had in their use that they are not applied in strengths that will destroy the plants. It is important that tents, rooms, or other receptacles in which objects are placed for fumigation, be as nearly air tight as possible.

26. CARBON BISULFIDE; "FUMA."

This is a clear, extremely volatile liquid with a very disagreeable odor unless obtained pure, when it is much more expensive. The fumes are heavier than air, so that it is always best to expose the liquid in the upper part of a building, or other receptacle containing objects to be treated. The fumes are explosive also when mixed with air, so that *great care must be taken not to bring fire near them.*

For the purpose of fumigating a building or other inclosed space containing growing plants, not over one pint of the liquid to 1,000 cubic feet of space should be used. For the destruction of insects in seeds, carpets or clothing it may be used much stronger.

To destroy ant hills, thrust a sharp stick down into the hill to a depth of eight or ten inches and then remove it and pour in two or three ounces of the carbon bisulfide; fill the hole with earth by stamping on it, and then throw over the hill a wet blanket to

hold down the fumes. Allow the blanket to remain for a half hour at least, and the ants will be dead. If the hill is a very large one it would be well to make two or three holes for the carbon bisulfide.

To kill prairie dogs, pour three or four ounces of the liquid on a ball of cotton and roll the latter down the prairie dog hole and quickly fill the mouth of the hole with dirt. Dry horse droppings or pieces of gunny sacking may be used in place of the cotton.

For the destruction of the woolly-louse of the apple, thrust a crow-bar or other sharp instrument into the ground to the depth of one foot or a little more, and at a distance of two feet from the crown of the tree and upon three sides of the tree. In each of these holes pour one ounce of the carbon bisulfide and close the holes quickly with damp earth. This is a cheap and effectual remedy and, if care is taken to have the holes made two feet from the tree and to have only about an ounce of the liquid put in a hole, there will be little or no danger of killing the trees.

This substance is expensive when purchased in small quantities at a drug store. It may be obtained quite cheaply if purchased in 50-pound lots, from Mr. Edward R. Taylor, Cleveland, Ohio. Write for prices.

27. HYDROCYANIC ACID GAS.

This gas has come into very general use, particularly in the orange growing sections of the country, for the destruction of scale insects. It may also be used for the destruction of insects in mills and in dwellings and in closed receptacles generally. Some of the best nursery men have adopted the excellent plan of fumigating all their nursery stock with hydrocyanic acid gas before shipping to their customers. This should always be done.

The chemicals of which this gas is made are cheap and are used in the following proportions:

Potassium cyanide (of 98 per cent. purity)	1 ounce.
Commercial sulfuric acid	1 ounce.
Water	3 ounces.

The above quantities are sufficient for a space of 100 cubic feet for the fumigation of dormant trees and plants (nursey stock). It may be used in the same strength, or even stronger, for the fumigation of mills, houses, clothing and the like.

The tent, building or receptacle in which the fumigation is to take place, should be as tight as possible. The less wind there is the better, if the fumigating room is not very tight.

The gas should be generated in an earthen jar, or wooden bucket or tub. *The chemicals must be added in the following order:* First put in the water; then add the acid; and, after the

water and acid have mixed, add the potassium cyanide. A good way to add the poison is to have it tied in a paper sack and placed upon a piece of board over the dish containing the acid and water, with a string attached to the sack and passing to the outside. Then, when everything has been made tight, a pull on the string will precipitate the sack of cyanide in the acid and a rapid escape of the poisonous fumes (HCN) will immediately take place, causing violent bubbling of the liquid. Filling ones lungs with these fumes would cause almost instant death, so great care must be taken not to breathe them. Fumigating rooms must be arranged so that doors or windows of some sort can be raised from the outside quickly. Then a thorough airing must take place before anyone enters.

It would require considerable space to give full directions for the fumigation of orchard trees, and, as there is little likelihood that such fumigation will be called for in Colorado for some time to come, I shall not take space to describe the process here. Those specially interested can obtain bulletins giving full directions from the Deparnment of Agriculture, Division of Entomology, Washington, D. C. Full directions can also be obtained in a book entitled "Fumigation Methods," by W. G. Johnson, and published by Orange Judd Co., New York.

SUBSTANCES THAT REPEL.

There are a number of substances that are more or less useful for the purpose of driving insects away from places where they would do harm if unmolested. I give below a few of the most important.

28. NAPTHALINE, GUM-CAMPHOR, AND MOTH BALLS.

Napthaline crystals are much used in insect boxes and in boxes or trunks where furs, feathers or woolen gooods are kept, for the purpose of keeping out insects that feed on these animal products. It is probably the best single chemical that can be used for this purpose. Gum-camphor is also much used for the same purpose and moth-balls are a combination of these two volatile substances. These materials cannot be used to kill insects, but only to repel them.

29. TOBACCO.

Tobacco, in the form of dust, or otherwise, is often used for the same purpose as the preceding, but to be effectual must be used quite freely.

30. ASHES.

Ashes, particularly from wood, are frequently used to dust

upon plants after a rain or while the dew is on and often result in the insects disappearing. Particularly is this true in case of flea-beetles and the cucumber beetle when feeding upon leaves. Ashes do not kill the insects, but they make the food distateful, so the insects are driven to other plants.

31. LIME, PLASTER, AND ROAD DUST.

These substances are also used like ashes as repellents, but are of little or no use for the destruction of insects, except, possibly, the pear and cherry tree slugs.

INSECT TRAPS.

There are many methods of trapping and destroying insects. One of the most common is the use of bright lights exposed at night.

32. LIGHTS.

The usual plan is to place a light over a dish of some sort that contains water with coal oil on top of it. Many night-flying insects are attracted by lights and may be destroyed by devices of this kind, but there are also many insects that fly at night that are not attracted by lights. Such an insect is the codling moth, though light traps are often recommended for its destruction. Among those insects that are readily attracted by lights might be mentioned the adults of the army worm, of the various cut-worms, the garden web-worms, the corn or boll-worm, and the beet-worms.

It is not infrequently the case that more of the beneficial insects are destroyed than of destructive species, and it is quite doubtful if lights are often of any great importance as a means of lessening the injury to crops by the destruction of insects.

33. SWEETENED WATER, CIDER, VINEGAR, ETC.

Some insects are attracted in considerable numbers to such substances as the above, but it is very seldom that the benefit derived from them will pay for the trouble and expense of using them. Mr. David Brothers, of Edgewater, Colo., reported excellent success capturing moths of the fruit-tree leaf-roller with weakened vinegar in pans in the orchard, and the codling moth is attracted to some extent to a mixture of molasses and vinegar placed in apple trees. The advantage of such baits for the capture of insects is usually greatly overstimated by those who use them.

34. BANDAGES.

Heavy cloth or paper bands placed about the trunks of apple trees are quite useful for the capture of the larvæ of the codling

moth that are leaving the apples and going in search of a suitable place to spin their cocoons. Burlap bands are cheap and seem to be as good as any. The writer took 1,481 codling moth larvæ under a single burlap band one season. Old gunny sacks cut into strips serve as well as anything. The band should not be less than four inches wide and should be composed of three thicknesses of the cloth.

The bands should be wrapped loosely about the trunks, the ends overlapped and held in place by a single carpet tack pushed in with the thumb.

If used against the codling moth they should be removed once in a week or ten days for the purpose of killing all the worms and then replaced.

The bands should be placed on the trees about the 10th of June in the warmer parts of the State, and about the 20th of June in the northern parts.

Bands of paper or wire screen are sometimes wrapped about the entire trunk to prevent the entrance of borers, as shown in Plate 4 Figs. 2 and 3.

35. HOPPER-DOZERS OR HOPPER-PANS.

For the purpose of catching jumping insects, especially grasshoppers, the hopper-dozer or hopper-pan is most useful. There are different methods of constructing these pans. A form used by Dr. Riley and illustrated by him many years ago is shown at Fig. 2. The pan in the illustration is entirely of sheet-iron, and is drawn across the field by two men or two horses. In the bottom of the pan is placed a small amount of water with kerosene on it. All grasshoppers that come in contact with the oil die. The back of the pan may be extended by means of stakes at the corners and a strip of cloth hung between them. Such an extension catches many grasshoppers that would otherwise escape. A modification of this pan is shown in bulletin No. 112, of this station by Mr. P. K. Blinn.

36. STICKY SUBSTANCES.

Bandages of sticky substances, such as printer's ink, "Dendroline," "Raupenleim," "Tree Tangle-Foot" or even cotton batting, are sometimes used to prevent insects from climbing trees. Where oily substances are used it is safer to put them on a bandage of stout paper, which is then wrapped about the trunk of the tree.

THE APPLICATION OF INSECTICIDES.

I think it best not to attempt to show types of apparatus for

the application of insecticides in this bulletin. There are so many manufacturers of spraying machinery now that it would be impossible to show pumps and other appliances made by more than a few of them. At the close of this article is a list of some of the more prominent dealers in spraying machinery. One who contemplates purchasing spraying apparatus should write to a few of these firms for catalogues, and then select what seems to be the pump or other machine that is best suited to his needs. Advertisements of other dealers in spraying machinery may be found in papers and magazines devoted to agricultural and horticultural pursuits.

APPLICATION OF DRY INSECTICIDES.

The upper surface of the leaves of all low plants can be easily treated with a dry insecticide by dusting it through a cheesecloth, or other thin muslin bag held in the hand. There are also various dust sprayers of large and small sizes upon the market.

By whatever means the dust is distributed it is best applied in the evening or early morning when foliage is slightly moistened with dew, or after a shower.

APPLICATION OF WET INSECTICIDES.

THE PUMPS.

Pumps with metal valves should be obtained for the application of insecticides or fungicides in liquid form, as the materials used harden or decompose leather valves so that they last but a short time. If the pump is to be used with a tank or barrel it is also important to have some kind of attachment that will keep the liquid agitated so the materials in suspension will not settle. A common error is to purchase a pump of too small capacity, because it is cheaper. A smaller, cheaper pump usually means less accomplished in a day with same help and a poorer job, with a greater expenditure of labor. And then, it is often important to complete the spraying in as short a time as possible after it is begun. To do this, a pump of large capacity with two or more leads of hose is necessary. The hose to which the nozzles are attached should be as light as possible and still have the requisite strength—a hose of good quality with heavy wall, but small caliber. Bucket pumps are sold by different dealers at prices ranging between about $2.00 and $8.00 in price. They are suitable for use among garden vegetables, shrubbery and all low plants, but should not be purchased for orchard work if one has more than a very few trees to treat.

If one has light spraying to do and is without help, the compressed air sprayers are very convenient. Large compressed air sprayers that derive their power from gearing attached to the

wagon wheel are specially adapted to the treatment of low plants, but I very much doubt if any spraying machines of this class upon the market are well adapted to the spraying of large orchard trees where the wagon must stand still a large proportion of the time while the spraying is going on.

Where large orchards are to be sprayed it is a matter of necessity and economy to use tanks that will hold 200 and 300 gallons, and pumps of large capacity. In such orchards gasoline power sprayers are most useful.

HOW TO SPRAY.

The first requisite for a good job of spraying is a pump that will give plenty of pressure in the hose. Then, if one has a good spraying nozzle and a liquid that is free from solid particles of a size to clog the sprayer, there will be no difficulty in getting a good spray. Barrels and tanks should always be filled through a strainer to avoid loss of time and annoyance through the clogging of nozzles.

A very fine spray is most economical of material and, for an even and thorongh distribution, is best, and is specially useful for the destruction of caterpillars, slugs and other insects that devour the foliage of plants. In case of the first spraying for the codling moth, however, I am still constrained to recommend as I have done for years, that the spray be a medium coarse one. By this I do not mean that the spray should be composed largely of large drops produced by the breaking up of a solid stream thrown forcibly into the air, and it should not be a fine mist or fog. A rather coarse Vermorel, or a good Bordeaux nozzle with a pressure of 100 or 125 pounds, will furnish such a spray as I refer to. When spraying is being done to destroy leaf-eating insects, care should be taken not to spray too long in one place, as this will result in the little drops that collect upon the leaves uniting and running off, carrying the poison with them. Here again this rule does not apply to the first treatment for the codling moth. In that application there should be but one end in view, and that to fill every blossom or calyx cup with the spray.

NOZZLES TO USE.

There are two types of nozzles that are used almost exclusively for the distribution of liquids. Perhaps the most popular among these are the Bordeaux and Seneca nozzles which throw a flat spray or a solid stream, and the Vermorel nozzles which throw a cone shaped spray which may be graded from medium coarse to extremely fine depending upon the pressure and the tip that is used upon the nozzle. It is a big advantage in noz-

zles of this class to have them joined to the connecting rod so they may be turned at any angle to the rod that is desired.

Any of these nozzles may be used singly or in batteries of two to four.

SOME LEADING MANUFACTURERS OF SPRAYING MACHINERY.

The Gould Manufacturing Co., Seneca Falls, N. Y.
The Deming Co., Salem, Ohio.
The C. E. Brown Co., 47 Jay Street, Rochester, N. Y.
The Friend Manufacturing Co., Gasport, N. Y.
The Hook-Hardie Co., Hudson, Mich.
Dayton Supply Co., Dayton, Ohio.
F. E. Meyers & Bro., Ashland, Ohio.
Bean Spray Pump Co., San Jose, California.
Spramotor Co., 107-109 Erie Street, Buffalo, N. Y.
Wallace Machinery Co., Champaign, Ill.
Morrill & Morley, Benton Harbor, Mich.
William Stahl, Quincy, Ill.
Fairbanks, Morse & Co., Denver, Colo.
Webber Engine Co.,
Dean Power Pump Co., Holyoke, Mass.
Field Force-Pump Co., Elmira, N. Y.
International Harvester Co., Denver, Colo.

Spray tank and hand pump used with excellent results by Senator J. W. Crowley, in his large orchards at Rocky Ford, Colorado.

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Fertilizer Experiments With Sugar Beets

By

A. H. DANIELSON

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Fertilizer Experiments With Sugar Beets

BY A. H. DANIELSON *

These experiments extended over three years, 1903, '04 and '05, and were to test the effect of fertilizers on the yield and quality of sugar beets and determine the effect from the different fertilizers used, under field conditions, and incidentally a number of other questions.

The tests of 1903-04 were on plats of one-tenth of an acre on the College farm, the plats used in the two years not being the same. The test of 1903 was of the nature of a preliminary test. A cooperative test with the Department of Agriculture formed one of the series of tests by the Bureau of Chemistry on the "Influence of Environment upon the Composition of the Sugar Beet." In 1905 corresponding tests were made with plats of six-tenths of an acre each in a field being raised under field conditions.

With the change in conditions brought by the cultivation of sugar beets the necessity which is being felt for artificial fertilizers, the exhaustion of the supply of sheep manure which has been the common source for a number of years, and the consequent realization of the future, if not the present, importance of fertilization, led to the tests here given.

Further and additional tests are desirable but it is believed the results are of value as they are.

Fertilizer Experiments in 1903.—The experiments conducted this season were in the nature of a preliminary test. The most complete series of plats was carried out on Field F, although there it is defective for an ideal series in that potash was left out except in the complete fertilizer as the experiment was planned too late to secure potash fertilizers.

The main object of this trial on Field F was to determine the effect of an excessive quantity of stable manure on beets, that of a fairly large application, and a small quantity with nitrate of soda, as compared with nitrate and phosphates alone and complete fertilizers. The result of the application of these materials in 1903 on this field is of more than ordinary interest because the after or residual effects of those applied in 1903 were tested for the two succeeding years. This data is given later.

*Assistant Agriculturist 1900-Jan. 1, 1906.

Crop History of Field F Used 1903.—The soil during 1901 and 1902 was very lumpy and especially in 1901 in poor physical condition because being plowed when very wet in 1900. The crops beginning with 1900 have been as follows:

1900—Plats of grain, sugar beets and corn.

1901—Sugar beets, 10 tons per acre.

1902—Grains 1413 pounds per acre, as follows, wheat 756 pounds. oats 271, barley 256, rye 62 and emmer 68 pounds.

1903—Sugar beets, 23.5 tons per acre, with manure and fertilizer.

1904—Sugar beets 17.6 tons per acre.

1905—Sugar beets 16.0 tons per acre.

The chemical analysis of the soil and subsoil from this field in 1903 and 1904, is given in Bulletins 95 and 96, U. S. Bureau Chemistry. The field was plowed the preceding fall (1902), disc harrowed the next spring on April 17. The fertilizer was applied on April 18, on all plats except 1, 2 and 3, by distribution with a drill on top of the soil and thorough harrowing with a drag harrow the long way of the plats. The cow manure on Plats 1, 2 and 3 was applied April 11-17, plowed under, harrowed on the 18th; the nitrate applied to Plat 3, when the manure had been plowed under, and harrowed into the soil together with the balance of the fertilizers on April 18. The seed was planted in rows twenty inches apart at the rate of fifteen pounds per acre on April 21; Plats 9 and 10 on April 27. The seed used was the variety known as Kleinwanzlebener grown in the State of Washington.

The cow manure used was without straw or litter, almost fresh, being only three and a half months old. It was the intention to use well rotted sheep manure, but none was available at the time. The bone meal was odorless, probably from steamed bones, or from "prairie bones." The two complete fertilizers consisting of nitrogen estimated as ammonia, 3.5—4.5%; available phosphoric acid 8-10%; potash 6-8%, were made up especially for this experiment by a fertilizer firm.

The beets were hoed and thinned from May 30 to June 4. On June 6-10 a heavy rain set in amounting to two inches in depth. Only two irrigations were given, on July 3 and 23. On August 10, Plat 10, with the excessive quantity of manure had the rankest growth of leaves. The three manured plats were more thrifty than those fertilized. Plat 5, bone meal and nitrate, show better growth than No. 4, with nitrate alone. Plat 8, with Basic slag appears better than the bone meal plat. Plat 10, complete fertilizer, looks better than the adjacent plat with less nitrogen from nitrates.

On November 7th the samples for analyses were taken. The harvesting and weighing began on November 14 with Plat No. 1, and was not finished until November 25. Plats 1 to 6, inclusive, were harvested November 14-16, although Plat 6 was not weighed until November 24. Plats 7-10, inclusive, were harvested and weighed November 23-25. Where the piles of beets could not be hauled and weighed at once they were covered with a layer of beet leaves and soil in order to

prevent freezing, and this also checked loss in weight from evaporation or drying out.

In applying the fertilizer and manure a strip two feet wide was left between each two plats to which nothing was applied. The rows of beets which grew on these strips were measured and harvested separately, weighed and counted. It will be seen that the average weight per beet in these rows between the plats is 0.7 of a pound less than the average weight given in Table 11 of the samples taken for analysis. While the estimated average tonnage per acre of these rejected rows is only 1.5 tons less than the actual average yields of all the plats. While no fertilizer was applied to the rows between the plats, practically a great deal would be worked within reach of the roots from that applied on both sides. From this data it is fair to assume, that in spite of great care in selecting the samples the average weight of the beets chosen for analysis to represent the sugar content and purity of each plat is about one-third larger than the average weight per beet of all the beets harvested. Nearly the same proportion is found between the twelve beets analyzed from Plat 6 and 366 beets dug for the same plat to note changes in maturing, reported in Table 17. However, the samples for analysis were selected in exactly the same way, so that the results were strictly comparable between themselves. This particular part of the data obtained shows that the 120 beets carefully selected to represent the whole field, were actually one third larger than 1,902 beets actually harvested.

TABLE 5.

FERTILIZERS ON FIELD F, 1903—ONE-TENTH ACRE PLATS

Plat No.	KIND OF FERTILIZER (Per Acre)	Cost of Fertilizer per acre	Yield of Clean Beets per acre	Sugar in Beets	Purity Co-efficient	Amt. Rec'v'd pr. acre for Beets	Amt. Rec'd less cost of Fertilizer
			Tons	Per Ct.			
1	Cow Manure........................60 tons	$45.00	24.11	13.1	81.0	$120.55	$ 75.55
2	Cow Manure........................30 tons	22.50	25.10	14.3	82.8	125.50	103.00
3	Cow Manure........................15 tons Nitrate of Soda...............150 pounds	15.75	25.25	14.4	84.2	126.25	110.50
4	Nitrate of Soda...............150 pounds	4.50	25.67	13.3	83.3	128.35	123.85
5	Nitrate of Soda...............150 pounds Raw Bone Meal...............200 pounds	7.10	25.61	14.9	83.8	128.05	120.95
6	No Fertilizer	....	21.46	15.1	85.0	107.30	107.30
7	Raw Bone Meal...............200 pounds	2.60	21.72	15.1	87.3	108.60	106.00
8	Thomas Phosphate...........400 pounds (or Basic Slag)	6.00	22.60	15.1	84.4	113.00	107.00
9	Complete Fertilizer...................... Nitrate of Soda.............50 pounds Dried Blood.................75 pounds Acid Bone Meal...........250 pounds Sulphate of Potash........50 pounds Carbonate of Potash......75 pounds (from Tobacco Ashes)	10.00	20.63	16.1	87.9	103.15	93.15
10	Complete Fertilizer...................... Nitrate of Soda.........100 pounds Dried Blood...............25 pounds Acid Bone Meal...........250 pounds Sulphate of Potash........75 pounds Carbonate of Potash......50 pounds (from Tobacco Ashes)	10.00	22.35	14.6	84.4	111.75	101.75
	Average..............	....	23.45	14.6	84.4	117.25	....

Some interesting results are shown from the expertments on Field F, in 1903, which can be a little better understood on account of the data obtained from the same plats for the next two years.

The difference in effect of the fertilizers and manures is greater than could reasonably be expected, when it is seen that this soil without manure or fertilizer was able to produce about 21.5 tons per acre.

TABLE 6.

DATA IN REGARD TO NEGLECTED ROWS BETWEEN FERTILIZED PLATS—FIELD F, 1903, FROM A MEAN OF 154 BEETS PER ROW

Row Between Plats Number	Estimated Yield Per Acre Tons	Average Weight Per Beets Pounds	Average Space Between Beets in Row Inches
0–1	24.14	1.67	11.3
1–2	25.85	1.51	9.6
2–3	20.50	1.16	9.0
3–4	27.01	1.59	9.6
4–5	22.58	1.32	9.6
5–6	19.16	1.20	10.3
[illegible]–7	19.24	1.30	11.0
[illegible]–8	20.5[illegible]	1.13	8.9
[illegible]–9	20.0	1.37	10.4
9–10	20.06	1.39	10.6
Averages	21.91	1.36	10.0

The effect of the excessive quantity of manure, Plat 1, was not as injurious to the quality of the beet as might be expected, only about two per cent less sugar and four points less in purity than the plats yielding less. The yield was also about a ton less than the other manured plats, while the beets although larger were of poorer shape.

The phosphoric acid used alone from bone meal and Basic slag, Plats 7 and 8, had very little if any effect on increasing the yield, although the Basic slag produced a ton more beets than the bone meal, which alone had practically no effect on the yield of beets. Used with nitrate of soda on Plat 5, we may presume it would be equally ineffective. The highest yields of any of the fertilizers was from the Plats 4 and 5 where nitrate of soda was used at the rate of 150 pounds per acre. This is a little more than the result from the plat of thirty tons manure or 4.1 tons more than the unfertilized plat. The nitrate of soda and fifteen tons of manure together, could not evidently increase the yield as 25.6 tons per acre was the limit of which this soil seemed capable.

Although the highest yield was from Plat 4, with nitrate alone, this is probably a trifle more than should be due to the nitrate, as a study of residual effects during the next two years seems to show that the soil conditions of this plat were slightly more favorable than those adjacent.

The results from the two complete fertilizers, Plats 9 and 10, are disappointing in yield. The highest yield was obtained from the one containing the larger quantity of nitrate of soda, 100 pounds, produ-

cing 1.7 tons more than the other with fifty pounds. It is very likely that the increase in Plat 10 was not entirely due to the larger quantity of nitrate in the complete fertilizer, as the yields from these plats during the next two years seem to show that the soil on Plat 10 had greater producing capacity than the adjacent No. 9. When it is considered that the two complete fertilizers contained nearly the same amount of nitrogen, the less nitrate in one being balanced by more dry blood in the other, and that the average yield of the two plats is the same as the unfertilized plat, it is hard to ascribe any effect at all upon the yield due to the nitrogen in the complete fertilizers. The curious fact appears here in the complete fertilizers, as well as during the tests of the next two years, that phosphoric acid and potach in the presence of nitrogen on our soils seems to neutralize to a great extent the beneficial effect of the nitrogen upon the yield when compared with the results from nitrogen used alone.

In the results from this experiment the highest sugar content and purity are associated with the lowest yields, the highest being found in the lowest yielding plat, No. 9, with the complete fertilizer, and the lowest sugar content in the highest yielding plat, No. 4, with nitrate of soda, with the exception of the one with excessive quantity of manure.

In this test also the phosphate form the bone meal, although ineffective upon the yield when used alone, with nitrate it seemed to a great extent to prevent the lowering of sugar content and purity, the nitrate and bone meal plat giving the highest yield of sugar per acre of any plat in the series, while the one with the excessive quantity of manure produced the least, the unfertilized plat giving the next lowest amount of sugar per acre.

FERTILIZER EXPERIMENTS IN 1904

On Field C3.—The fertilizer experiment for this season was planned to include a series of all three elements, used in about the proportion which experiments elsewhere had proven to be fair average quantities. As nitrate bone meal had shown only negative results the previous year, acid treated phosphate rock or superphosphate as the source of the phosphoric acid was used, and this season it was planned to give a more thorough test with nitrate of soda which had given the best results in 1903. The same, as well as twice the amounts used in 1903 were given in one application at the time of planting, and also in three applications. High grade sulphate of potash was employed as a source of the potash. Refuse lime cake from the sugar factory was also used on one plat. This is the refuse lime which has been used in refining and purifying the juices in sugar making, and contains a small proportion of phosphoric acid and nitrogen, large quantities of which are used as a fertilizer on the sugar beet soils of Germany and it was thought it might have some effect upon our soils. Such, however, proved not to be the case. The thoroughly air dried lime cake was

scattered over the land at the rate of 4.7 tons per acre and thoroughly harrowed into the soil three times before seeding.

The following analysis of lime cake is given in the Beet Sugar Gazette of July 20, 1903:

	Per Cent
Potash	.05
Phosphoric Acid	2.08
Nitrogen	.26
Lime Carbonate	54.61
Oxide of Lime	13.32

The fertilizers were applied at the time of seeding with the seed, by the use of an attachment to the regular seed drill. The fertilizer falls in such a way that a slight layer of soil falls over the seed and the fertilizer over this layer and a thicker layer of soil covers fertilizer and all. It will be seen that in this way a large amount of concentrated chemicals is applied directly with the seed. The beet seed has germinated quicker and stronger when applied with the fertilizer in this way than when no fertilizer was used. As all the materials were easily soluble examination showed that it had been practically absorbed by the moist soil in a few days before germination of the seed was fairly in progress. The method of applying fertilizers with a drill was changed also because it was realized that should fertilizers be found desirable to use to any extent on sugar beets, the cheapest method of practice would be the most desirable.

It was planned to apply the materials used singly or in mixture in the following quantities:

Nitrate of soda 150 pounds, and the same quantity in three applications of fifty pounds each, one portion applied at time of seeding, and the other two portions at different periods later in the season.

Nitrate of soda 300 pounds, and in the same quantity in portions of 100 pounds each in three applications, as before.

Acid phosphate rock, 300 pounds.

Sulphate of potash, 100 pounds.

However, it was found that the three materials differed in texture and consistency, no two mixtures being alike, it was impossible to regulate the drill attachment to sow the exact quantity intended.

Soil History of Field C3, 1904.—The most practical benefit from the results of an experiment of this kind would doubtless be derived if carried out on soil which had been more or less exhausted by previous beet crops, but none such was available.

The land finally chosen was some which had borne alternate crops of grain and corn for the previous five years without manure, and had not been in alfalfa for at least ten years, as far as known. On such a soil it would be natural to expect that the nitrogen would be nearly exhausted, and the high return from the nitrogen in the fertilizer is not surprising.

The previous crops on Field C3 for ten years, as far as known, have been as follows: 1893 red clover; 1894 barley, rye and oats; 1895 corn; 1899 grain; 1900 corn; 1901 emmer; 1902 Kaffir corn; 1903 wheat; 1904 beets, fertilizer experiment.

The land was plowed in the spring and prepared for planting in the usual way. The seed used was Kleinwanzlebener grown in the State of Washington, planted at the rate of thirty pounds per acre, with the fertilizer applied April 27. A heavy rain occurred from April 30 to May 3, amounting to four inches, and had the result of forming a thick crust on the surface, making it very difficult for the germinating seed to break through. This was assisted somewhat by the use of a roller, but the final result was that although uniform the stand of beets was rather thin, with a distance of 12 to 15 inches between beets after thinning.

On Plats 8 and 9 the first top dressing of nitrate of soda was applied June 11, and the second July 29. All the plats which had received nitrate of soda alone or in combination were in better growing condition, July 15, with greener, larger leaves than those without it, except Plat 11, where the action of nitrate was only slightly apparent. This thrifty appearance was in about the proportion in which the nitrate had been used. This difference in appearance continued until harvest.

The beets were weeded by hand and cultivated and irrigated three times, samples for analysis taken on October 15, and plats harvested October 15, 16 and 17.

TABLE 9.

FERTILIZERS ON FIELD C3, 1904—ONE-TENTH ACRE PLATS—PLANTED APRIL 27

Plat Number	Total Am't of Fertilizer used per acre	KIND OF FERTILIZER Per Acre	Cost of Fertilizer per acre	Yield of Clean Beets per acre	Sugar in Beets	Purity Coefficient	Am't Received per acre for Beets	Am't Received Less Cost of Fertilizer
	Pounds	Pounds		Tons	per ct.			
1	240	Nitrate of Soda....................144 Sulphate of Potash................ 96	$ 7.34	14.75	16.8	89.1	$78.75	$66.41
2	128	Sulphate of Potash................128	4.03	12.60	15.3	86.6	63.00	58.97
3	435	Sulphate of Potash...........109 Acid Phosphate Rock.............326	6.69	12.77	15.3	88.8	63.85	57.16
4	330	Acid Phosphate Rock.............330	3.30	11.53	14.6	86.2	57.65	54.35
5	495	Acid Phosphate Rock.............330 Nitrate of Soda....................165	8.25	14.94	14.3	89.0	74.70	66.45
6	....	No Fertilizer..........................	....	10.98	15.6	87.9	54.90	54.90
7	140	Nitrate of Soda....................140	4.20	13.16	15.2	88.0	65 80	61.60
8	187	Nitrate of Soda....................97 June 11............45 June 29............45	5.60	13.92	15.3	86.1	69.60	64.00
9	431	Nitrate of Soda....................111 June 11............160 July 29............160	12.93	15.30	15.4	88.8	76.50	63.57
10	580	Nitrate of Soda..................4 0 (a) June 11.......160	17.40	15.30	14.8	85.5	76.90	59.50
11	578	Complete Fertilizer.................. Nitrate of Soda................158 Acid Phosphate Rock..........315 Sulphate of Potash............195	11.20	11.72	16.4	89.0	58.60	47.40
12	9360	Lime Cake.................4.68 tons (air dried)	....	9.73	15.8	88.1	48.65	....
		Average...............	....	13 06	15.4	87.8	65.30	....

(a) Applied by mistake.

Comments on Results of Fertilizer Experiment 1904.—The most important points as indicated by the results of this experiment are the higher yields wherever nitrate was used either alone or in combination except where used in the "complete" fertilizer. There is nothing to indicate that there was any benefit from applying the same amount of nitrate in several doses. In the case of Plat 8 the higher yield over Plat 7 is undoubtedly due to the larger amount used in the three applications. In the case of Plat 10 which accidentally received a top dressing where it was not intended, the larger total quantity used did not increase the yield, although it lowered the sugar content and purity slightly. There is also a little evidence that sulphate of potash had some effect and that it at least did a little more than pay for itself, while the acid phosphate had very little if any effect upon the yield. It is also seen that the effect of nitrate was not influenced by potash or the acid rock when used separately with nitrate, but when all three were used together in the complete fertilizer, the result is negative, as was found in the experiment of the previous year. Looking at this result in one way there seems to be a neutralization of the action of nitrate in presence of potash and phosphate together.

The limit of the most profitable application of nitrate of soda with the soil and conditions of this experiment appears to be about 175 pounds. Taking into consideration all the plats where the increased yield seems due to a reasonable quantity of nitrate a moderate estimate would be that on land capable of producing 11 to 15 tons without fertilizers, the profit can be increased from $9 to $10 per acre by the use of said amount of nitrate of soda. The larger quantities, even the extreme amount of 580 pounds, although giving a profit above the cost of application, did not give returns in proportion to the amounts used, after deducting the cost.

The results of the lime cake applied was ineffective if it did not actually decrease the yield. In this experiment there is no indication to show that phosphoric acid used with nitrate of soda, increased the sugar content of the beet over nitrate alone, as in the experiment of the previous year. If anything, this effect, is due to potash with nitrate, in this experiment.

The sugar content and purity is generally uniform and satisfactory, being the highest on Plat 1 with nitrate of soda and potash, and Plat 11 with all the elements. In this experiment, perhaps for the reason that the average yield, thirteen tons, of all the plats is below the average of this district, there is no connection between higher yields and high sugar content and purity, or vice versa.

FERTILIZER EXPERIMENTS IN 1905

The experiment this season with fertilizers of sugar beets was conducted on a large area, and in cooperation with a farmer growing beets exclusively and under his control as regards cultural methods. The experiment can therefore be considered as under the conditions of ordinary farm work, and none of the refinements possible in small plat work was attempted, with the exception of the accurate appli-

cation of the fertilizers and weighing the beets from each plat separately. The weights and tare were taken at the factory in exactly the same manner and in the regular way all beets are received.

A sufficient number of average beets were taken from each load as delivered, or about six per load, to make a total sample of eighteen beets per plat for analysis as to sugar content and purity. The only reason for the analysis and taking samples in this manner was to determine whether any of the beets as delivered would be unsatisfactory. No other comparisons can be made as to the analysis, as there was several weeks difference in the time of harvesting the various plats and also in exposure to the drying influences of the air, the beets having been dug and placed in piles.

The difference between results from the various fertilizers, when the experiment is conducted in this manner must be rather great to be of value, but when large should be convincing. The results, however, only corroborate those trials made in previous years on smaller areas.

The location of this tract is about one quarter of a mile from the grounds where the previous tests reported were made, and apparently of the same character, if anything more productive. The field where the experiment was conducted was ideal in location and slope being very uniform of surface, smooth, with just sufficient grade to facilitate uniform flow of water in irrigation. The plats were made long in proportion to width, a point of great value in comparative tests, each plat occupying twelve rows, twenty inches apart, or nearly twenty feet wide to 1240 feet or nearly a quarter of a mile long, and therefore nearly sixty-three times as long as wide. The average area of the plats was six-tenths acre to each plat.

The experiment is of considerable value for the reason that this soil had already previously produced three successive crops of sugar beets, the experimental crop being the fourth, and without manure on the portion where the plats were located, except on a small strip running across all the plats at one end, where manure had been used for two years. This test is of particular value because fertilizers, if effective, are needed when the soil is becoming exhausted by successive crops of sugar beets. The returns from unfertilized and unmanured plats are disappointing for the purpose of the experiment by too high yields, for the various elements in the fertilizers do not have an opportunity to demonstrate what each element can really do on exhausted beet soil. That the soil was not exhausted is well seen. It also shows the staying qualities of our Colorado soil with a presumably exhausing crop.

The land had previously been in alfalfa for a number of years, with a crop of wheat succeeding the alfalfa, and before the first crop of beets as follows: 1900 alfalfa, of several years standing; 1901 wheat; 1902 sugar beets, 1903 sugar beets; 1904 sugar beets, 17.5 tons per acre; 1905 sugar beets, as reported in this experiment. The average yield on twenty five acres, including the fertilizer experiment, and balance of manured land in 1905, was nearly 16.5 tons per acre.

The fertilizer used and the quantities of each intended for application, alone and in combination are as follows:

Nitrate of soda, 200 pounds and 400 pounds.

Sulfate of potash (high grade) 100 pounds.

Acid bone meal, 200 pounds.

Acid bone meal was stated to have been made up in proportions as follows:

1800 pounds steamed bone meal.

750 pounds 50 Beaume sulphuric acid.

All the fertilizers were passed through a one-fourth inch sieve and well mixed in the proportion desired. The land was plowed in the spring and prepared for planting in the usual way, which was done on May 1-2, sowing the fertilizer along with the seed by an attachment to the beet drill, approximating very closely the total amount desired per acre of each ingredient. The seed used at the rate is sixteen pounds per acre was the German imported Kleinwanzlebener supplied by the sugar factory. As before noted the seed germiniated quicker and stronger on the fertilized than the unfertilized plats. Even the large quantity of 426 pounds per acre sodium nitrate with the seed had no injurious effect upon the germination. The beets were hoed and thinned once, and cultivated and irrigated three times each. The two plats of nitrate of soda alone, especially the larger quantity, were distinguished by thrifty growth throughout the season, the larger quantity having apparently twice as large tops and much larger sized beets than any other plat.

The harvest began October 24 and was finished November 29. Two-thirds of Plat 11 was weighed October 26, and the balance November 13, for the reason that a snowstorm set in just as harvesting began, followed by a freeze, the temperature falling to eight below zero. The fields were protected by the fallen snow and no injury resulted only that harvesting was delayed ten days. When digging could be resumed, another freeze being feared, all the beets were plowed out as fast as possible, progressing from Plat 11 towards Plat 1. They were placed in piles and covered with tops. It thus occurred that Plats 4 to 1 inclusive were weighed without much loss or shrinkage, and Plats 5 to 10 inclusive, probably suffered considerable loss through shrinkage, some of the beets being exposed over three weeks before being weighed. These facts must be considered in comparing results.

Comments on Result of Fertilizer Experiment in 1905.—The most striking items of consideration in the experiment of 1905 are that the unfertilized plats gave the lowest yields in the series, and on an average those containing nitrogen the highest. Some allowance must be made for the fact that Plats 1 to 3 gave nearly as high yields as those containing nitrate, as all the conditions were in favor of Plats 1 to 3 showing greater weights, being harvested and weighed from two to three weeks later than the balance of the plats which were being exposed to shrinkage during that time.

There are also two discrepancies in the fact that while phosphate

and potash, all conditions being considered, gave very small increase when used singly, the two used together produced higher yield than either alone; the other being the small yield of Plat 7 where the smaller quantity of nitrate was used alone, when compared with other plats containing nitrate.

TABLE 10

FERTILIZERS ON THE ANDREWS FARM SOUTH OF LAKE PARK, 1905—SIX-TENTH ACRE PLAT

Plat Number	KIND OF FERTILIZER Per Acre	Cost of Fertilizer per acre	Yield of Clean Beets per acre	Sugar in Beets	Purity Coefficient	Amount Received per acre for Beets	Amount Received Less Cost of Fertilizer	Factory Tare was per ct	Av. Wt. of 18 Sample Beets per Beet ozs.
	Pounds		Tons	per ct					
1	Acid Bone Meal........193	$ 1.93	15.61	15.2	87.8	$78.05	$76.12	10.	31
2	Acid Bone Meal........192 Sulphate of Potash........96	5.58	16.81	15.4	88.0	84.05	78.47	10.	28
3	Sulphate of Potash........142	4.47	15.14	15.0	86.2	75.70	71.23	10.8	29
4	Sulphate of Potash........100 Nitrate of Soda........199	9.12	17.89	14.2	85.8	89.45	80.33	12.0	34
5	Nitrate of Soda........426	12.78	18.60	14.6	85.7	93.00	80.22	9.	26
6	No Fertilizer........	......	14.76	14.0	87.2	73.80	73.80	14.	24
7	Nitrate of Soda........212	6.36	16.16	15.0	85.3	80.80	74.44	10.	29
8	Nitrate of Soda........214 Acid Bone Meal........215	9.28	15.93	15.2	85.3	79.65	70.37	15.	24
9	Complete Fertilizer........ Acid Bone Meal........187 Nitrate of Soda........187 Sulphate of Potash........94	11.06	14.71	15.0	86.3	73,55	62.49	15.	26
10	No Fertilizer........	......	12.18	15.2	84.9	60.90	60.90	13.2	18
11	No Fertilizer........	......	13.63	15.2	88.7	68.15	68.15	8.6	30
	Average........	......	15.58	14.9	86.5	$77.90	......	......	27

The effect of complete fertilizer although more favorable than in the previous two years, indicates the same general tendency, in the apparent neutralization of the action of nitrate of soda in the presence of potash and phosphoric acid together, as derived from the fertilizer; the yield being about the same as the unfertilized plat, two plats removed, less than the nitrate and acid bone meal plat adjoining, but much more than the unfertilized plats adjoining on the other side.

All the results seem to indicate that the increase in yields was chiefly due to nitrate of soda used alone or with the other elements, and that there was no additional net profit from the application of over double the quantity of the smaller amounts.

Taking all the factors into consideration a careful comparison of Plats 5 and 6 and conservative estimates seem to indicate that on soil capable of producing from 13.5 to 14.5 tons per acre without fertilization, about 200 pounds of nitrate of soda caused a gross increase of $20 per acre with beets at $5 per ton, or a net increase over the cost of fertilizer of about $6 to $7 per acre.

In appearance the size and shape of the beets grown in this ex-

periment were excellent, the average weight per beet of the 200 samples being twenty-seven ounces, or 1.7 pounds.

The sugar content and purity of the beets analyzed were in general satisfactory, and about as high as the average of the district this season (1905). Both the sugar content and yield of sugar beets were somewhat below the average of previous seasons in Northern Colorado and elsewhere, largely due to the late spring and copious rains in the earlier part of the growing season, which caused a more luxuriant growth of tops or leaves than usual, but which proved rather unfavorable to the production of a proportionate increase in weight of the sugar beet crop.

RESIDUAL OR AFTER EFFECTS OF MANURES AND FERTILIZERS

Experiments on Field F, 1903-4-5.—From the plats on Field F, to which manures and fertilizers were applied in 1903, the data of which is given in Table 5, the beets were harvested separately and other data secured in the following two years in order to determine the residual or after effects of the manures and fertilizers used. Some very interesting facts were disclosed, that data being given in Table 11.

TABLE 11.

RESIDUAL ON AFTER EFFECTS OF MANURE AND FERTILIZERS APPLIED ONE YEAR ONLY ON FIELD F, 1903

Plat Number	KIND OF FERTILIZER Applied in 1903 only	Yield in Tons per acre				Quality of Beets								
						1903				1904				1905
		1903	1904	1905	Average 3 Years	Sugar in Beet	Purity Coeff.	Av. Weight per Beet	Per Cent Tops	Sugar in Beet	Purity Coeff.	Av. Weight per Beet	Per Cent Tops	Not Determined
	Amt. per acre--Tons					per ct		lbs		p. c		lbs		
1	Cow Manure............60	24.11	19.68	15.82	19.87	13.1	81.0	2.44	72	15.2	84.3	2.13	41.4	....
2	Cow Manure............30	25.10	20.31	14.57	19.99	14.3	82.8	2.00	47	15.8	85.0	1.18	42.3	....
3	Cow Manure............15 Pounds Nitrate of Soda.......150	25.25	19.13	16.94	20.44	14.4	84.2	1.51	51	15.9	86.3	1.33	28.1	....
4	Nitrate of Soda........150	25.67	19.28	17.78	20.91	13.3	83.3	2.56	46	14.9	87.4	1.18	37.1	....
5	Nitrate of Soda........150 Raw Bone Meal........200	25.61	17.98	16.10	19.89	14.9	83.8	2.03	47	16.2	86.5	1.13	39.7	....
6	No Fertilizer............	21.46	16.94	17.07	18.49	15.1	85.0	2.04	33	15.8	87.6	1.04	40.8	....
7	Raw Bone Meal.......200	21.72	16.17	16.14	18.01	15.1	87.3	2.23	31	16.0	87.5	1.22	38.1	....
8	Thomas Phosphate....400 (or Basic Slag)	22.60	15.55	14.61	17.59	15.1	84.4	2.13	37	14.4	87.3	1.32	39.6	....
9	Complete Fertilizer...... Nitrate of Soda.......50 Dried Blood..........75 Acid Bone Meal......250 Sulphate of Potash..50 Carbonate of Potash.75 (from Tobacco Ashes)	20.63	14.57	15.18	16.79	16.1	87.9	1.59	42	15.2	87.1	1.23	42.6	....
10	Complete Fertilizer...... Nitrate of Soda......100 Dried Blood..........25 Acid Bone Meal......250 Sulphate of Potash..50 Carbonate of Potash.75 (from Tobacco Ashes)	22.3[illegible]	16.49	15.99	18.2[illegible]	14.6	84.4	2.12	45	15.0	84.3	1.08	40.8	....
	Averages........	23.4[illegible]	17.59	16.02	19.01	14.6	84.4	2.06	45.3	15.4	86.3	1.23	39.0	....

Some facts as to the effects of cow manure will be especially interesting. A positive residual effect is noted the second year. The difference between the manured plats and the other plats which had received more of less ineffective fertilizers was even more largely in favor of the manure the second year, than the year of its application. For instance the difference between the averages of the three manured Plats 1, 2 and 3, and the unfertilized or ineffectively fertilized Plats 6, 7 and 8 in 1903, the year of application, was 3.2 tons and the second year 3.5 tons, in favor of the manure.

In the third year after application the residual effects entirely disappeared in the case of the cow manure, the difference in fact between the plats just given, being a small fraction or 0.16 tons against the manure.

While there are interesting after effects the second year of the application of manure, the yields are not proportionate to the amounts used in the previous year, being only slightly more with sixty and thirty tons than with fifteen tons.

Thus if the cost and the expense of the application are deducted, there is little if any net profit from the increased yield of sugar beets in the year of the application, of a moderate or large amount of manures, but that the returns are found in the succeeding year therefore clear profit except for the expense of topping and delivery of the extra quantity.

It is also seen that large to excessive quantities of manure used are sheer waste, and that returns as good if not better are obtained with medium amounts.

In the case of any residual effect from nitrate of soda where it was used in any quantity alone or with potash or phosphoric acid, leaving out its use in Plat 3, with manure, which obscures its effects, in Plats 4, 5 and 10, on the face of the returns, there actually appears to be beneficial after effects, although this is probably a coincidence due to some inherent difference in the quality of soil on these plats for it would be almost absurd to suppose that an easily soluable, and in the soil, unstable compound like nitrate, would remain until a second season.

Comparison of the sugar content of the beets of the three manured plats and the unmanured Plats 6, 7 and 8, previously mentioned, shows a difference between the averages the first year of 1.7 per cent, and the second year only 0.3 per cent. The difference in yields between the two was greater the second year than the first, but of course with a lower average yield all around. The purity coefficient shows a difference of 2.5 and 1.9 when compared in the same way. The point of the whole matter is that in the second year the sugar content and purity of the beets from the manured plats, with higher yield, was just about as good as that of the unmanured plats with lower yield, which was not the case the first year the manure was applied.

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ganda; Armour Fertilizer Works, Omaha; German Kali Works, New York; and Colorado Packing and Provision Company, Denver.

Relation of Size and Amount of Fresh Beet Tops to Quality of Sugar Beets.—In the samples taken for analysis in all the fertilizer experiments of 1903 and 1904, the beets were carefully cleaned, weighed and the tops consisting of crown and leaves, removed in the approved manner, and beets weighed again. Considerable data was then secured of value, especially as regards the amount of beet tops, in relation to the size of the beet, quality and yield and fertilizers used. The detailed data is given in Tables 12 and 13, and the summary in Table 14.

TABLE 12.

DATA AS TO THE RELATION OF SIZE AND AMOUNT OF FRESH TOPS TO QUALITY OF SUGAR BEETS, 1903

	Plat Number	Number of Beets in Sample	Average Weight Per Beet in Pounds	Per Cent Tops	Sugar in Beet	Purity Co-efficient
	2	12	2.17	40	15.6	85.6
	3	12	3.13	55	15.0	83.6
FIELD C	4	12	2.25	43	15.1	84.4
Total Area Sampled	5	12	2.46	58	14.8	83.2
0.6 Acres	6	12	2.33	52	15.5	85.4
	7	12	2.33	46	15.7	86.4
Averages		72	2.45	49.2	15.3	84.7
Field F.—1 Acre	1	12	2.44	72	13.1	81.0
	2	12	2.00	47	14.3	82.8
	3	12	1.51	51	14.4	84.2
	4	12	2.56	46	13.3	83.3
	5	12	2.03	47	14.9	83.8
	6	12	2.04	33	15.1	85.0
	7	12	2.23	31	15.1	87.3
	8	12	2.13	37	15.1	84.4
	9	12	1.59	42	16.1	87.9
	10	12	2.12	45	14.6	84.4
Averages		120	2.06	45.3	14.6	84.4
Field E.—0.2 Acres	1	12	1.67	41	15.1	87.3
	2	12	1.88	44	15.3	85.9
Averages		24	1.78	42.5	15.2	86.6

There does not appear to be any definite relation between these various factors, although there are some indications that the larger beets with large percentage of tops have somewhat lower sugar content and purity. The opposite is true in a few cases.

Beet tops have come to be of considerable value, being pastured by cattle and sheep with success. The value of the beet tops thus pastured has a market price at present of from $1.00 to $3.00 an acre and sometimes more. As to palatability it has been found that sheep

will readily leave alfalfa hay for beet tops, but that the crowns are not readily eaten. Cattle, however, will eat the crowns clean.

TABLE 13.

DATA AS TO THE RELATION OF SIZE AND AMOUNT OF FRESH BEET TOPS TO QUALITY OF SUGAR BEETS, 1904

	Plat Number	Number of Beets in Sample	Average Weight Per Beet Pounds	Per Cent Tops	Sugar in Beet	Purity Co-efficient
Field C.3–Area 1.2 Acres	1	12	1.28	39.0	16.8	89.1
	2	12	1.12	42.5	15.3	86.6
	3	12	1.29	41.3	15.3	88.8
	4	12	1.42	41.8	14.6	86.2
	5	12	1.70	41.1	14.3	89.0
	6	12	1.44	43.4	15.6	87.9
	7	12	1.58	37.0	15.2	88.0
	8	12	2.24	46.9	15.3	86.1
	9	12	1.93	51.9	15.4	88.8
	10	12	2.66	51.1	14.8	85.5
	11	12	1.28	36.6	16.4	89.0
	12	12	1.23	41.5	15.8	88.1
Averages		144	1.60	43.8	15.4	87.8
Field F.—Area 1 Acre	1	12	2.13	41.4	15.2	84.3
	2	12	1.18	42.3	15.8	85.0
	3	12	1.33	28.1	15.9	86.3
	4	12	1.18	37.1	14.9	87.4
	5	12	1.13	39.7	16.2	86.5
	6	12	1.04	40.8	15.8	87.6
	7	12	1.22	38.1	16.0	87.5
	8	12	1.32	39.6	14.4	87.3
	9	12	1.23	42.6	15.2	87.1
	10	12	1.08	40.8	15.0	84.3
Averages		120	1.23	39.0	15.4	86.3
Field B.—Area 1 Acre	W	12	1.92	54.0	14.6	89.0
	N	13	1.57	53.2	13.9	86.8
Averages		26	1.75	53.6	14.3	87.9

TABLE 14.

SUMMARY OF AMOUNTS OF BEET TOPS AND QUALITY OF SUGAR BEETS

	FIELD	Area Acres	Number of Determinations	Total Number of Beets Analyzed	Average Weight Per Beet Pounds	Yield of Beets Per Acre Tons	Green, Fresh Tops: Per Acre Tons	Green, Fresh Tops: Pounds Per Ton of Beets	Green, Fresh Tops: Per Cent of Tops	Sugar in Beet	Purity Coefficient
1903	C1	0.6	6	73	2.45	27	13.28	984	49.2	15.3	84.9
1903	F	1.0	10	120	2.06	23	9.96	906	45.3	14.6	84.6
1903	E	0.2	2	24	1.78	20	8.50	850	42.5	15.2	86.6
1904	C3	1.2	12	144	1.60	13	5.70	876	43.8	15.4	87.8
1904	F	1.0	10	120	1.23	18	7.02	780	39.0	15.4	86.3
1904	B	1.0	2	25	1.75	22	11.80	1073	53.6	14.3	87.9

The average weight per beet of all samples analyzed is found to be 1.76 pounds, and the average fresh green tops 44.2, from 42 determinations of 12 samples each. The average yield of 19.8 tons will thus produce 8.75 tons of fresh green tops.

The loss of weight in thorough air drying or curing has not been determined, but it is believed that one-eighth of the green weight would be a reasonable estimate. Calculating the green tops at 44.2 per cent of the net weight of beets the relation of tons per acre and tops would be as follows:

Beets per acre tons	Fresh green tops per acre tons	Estimated Tons air dry weight per acre
20	8.84	1.10
15	6.63	.83
10	4.41	.55

TABLE 15.

YIELD OF FRESH BEET TOPS BY GATHERING AND WEIGHING ALL THE TOPS AFTER HARVESTING BEETS

FIELD F. 1904—ONE TENTH ACRE PLATS,

Plat No.	Yield of Beets Per Acre Tons	Tops Per Acre Tons	Tops Per Ton of Beets Pounds	Per Cent Tops
1	19.57	10.65	1088	54.4
2	20.23	5.85	578	28.9
3	19.03	5.88	618	30.9
4	19.20	4.64	484	24.2
5	17.90	5.11	571	28.5

NOTE—Tops on Plats 2 to 5 were allowed to remain on the ground from three to five days after topping.

The data given in Table 15 was obtained by gathering and weighing all the tops of a known area, with yield of beets, from one to five days after topping. A considerable per cent was lost in this way, being impossible to gather. There was also considerable loss in weight from evaporation in those last gathered. It will be seen that the percent of tops from Plat 1 with an excessive amount of leaves by actually gathering all the tops, is greater than the figure obtained from the sample beets, the sample showing forty-one per cent and the gathered leaves fifty-one per cent of the beets harvested.

Data in Regard to Maturing Period of Sugar Beets.—The data given in Tables 16, 17 and 18 was obtained in cooperative work with the Bureau of Chemistry, Department of Agriculture, Washington, D. C. All the analyses of 1902 were made by the Bureau, and that of other years in the laboratory of the local sugar factory by the courtesy of Mr. Booraem.

The samples were taken every week beginning with the last week in September and continuing until the beets were all harvested or until prevented by freezing of the ground. The manner of taking the samples consisted of digging all the beets from a fifty foot row, each successive digging adjoining the other, counting, cleaning, par-

tially topping, weighing the beets and analyzing twenty-five average specimens. In the samples shipped to Washington the sugar content and purity is based on the first weight of the beets, thus allowing for evaporation and shrinkage. The weight per beet and estimated yield per acre is a little higher than the actual for the reason that all the crowns were not removed in trimming. The difference is also seen in the actual yield of each plat when harvested, being somewhat less than the tonnage from the samples.

TABLE 16.

SAMPLES FROM FIELD D, 1902

Date of Sampling	Mean Weight of Topped Beets in		Estim'd Yield Per Acre Tons	Sugar in Beet Per Cent	Purity Co-efficient
	Ounces	Pounds			
September 17	19.6	1.23	20.2	12.9	80.5
September 26	24.5	1.53	26.0	12.1	78.3
October 3	25.0	1.56	25.7	10.5	74.0
October 10	27.0	1.69	27.3	9.8	66.6
October 17	27.4	1.71	24.2	13.2	81.4
October 24	22.9	1.43	25.5	14.3	83.8
October 31	27.0	1.69	31.8	13.9	80.4
November 7	22.0	1.38	24.4	14.7	87.0
November 14	23.4	1.46	26.6	14.4	84.3
November 21	26.9	1.68	28.6	13.7	78.0
November 28	26.1	1.63	26.7	13.6	79.1
December 5	27.2	1.70	25.7	13.0	79.7
Average	24.9	1.56	26.0	13.0	79.4

Sept. 12, killing frost. Sept. 20-21, 6 inches rain.
Yield of whole Plat when harvested was 25.4 tons.
Average space between beets 9.3 inches but with 9% of the beets missing the majority were 8.56 inches apart.

TABLE 17.

SAMPLES FROM FIELDS F AND E, 1903

Field F. Plat 6

Date of Sampling	Mean Weight of Topped Beets		Est. Yield Per Acre Tons	Sugar in Beet Per Cent	Purity Coeffi.
	Ounces	Pound			
September 26	19.8	1.24	20.4	14.8	82.0
October 6	22.9	1.43	19.7	16.7	83.6
October 10	23.5	1.47	24.2	15.7	81.1
October 17	17.4	1.09	21.8	18.5	81.6
October 26	25.1	1.57	22.2	16.2	85.3
November 3	25.9	1.62	23.8	15.9	81.7
Average	22.4	1.40	22.0	16.3	82.5

Yield of whole plat when harvested 21.5 tons. Spacing 8.2 inches.
Nov. 7. Sugar in beet 15.1. Purity 85.0.

(TABLE 17, CONTINUED.)

On Field E					
September 26	1.47	23.5	20.7	13.8	79.1
October 6	1.40	22.4	21.2	15.3	81.5
October 10	1.53	24.5	19.6	15.6	79.7
October 17	1.45	23.2	22.8	14.4	80.4
October 26	1.25	20.0	21.7	16.2	87.3
November 3	1.67	26.7	25.3	15.1	77.6
Average	1.46	23.4	21.9	15.1	80.9

Yield of whole plat when harvested 19.8 tons. Spacing 10.5 inches.
Nov. 7. Sugar 15.1% Purity 87.3.

TABLE 18.

SAMPLES FROM FIELD F, PLAT 6, 1904

Date of Sampling	Mean Weight of Topped Beets in		Est. Yield Per Acre Tons	Sugar in Beet Per Cent	Purity Coeffi.
	Ounces	Pounds			
September 22	16.2	1.01	17.6	15.4	83.5
October 12	18.1	1.13	18.8	16.2	88.4
October 15	16.0	1.00	16.7	16.7	87.9
October 20*	16.6	1.04	....	15.8	87.6
October 22	16.8	1.05	18.2	16.4	89.1
Average	16.7	1.05	17.8	16.1	87.3

* Average of 12 samples.
Yield of whole plot when harvested 16.9 tons.
Average space between beets 8.9 inches.

The data secured offers some interesting evidence as to the progress of ripening in the sugar beet, the most striking being the comparatively slight increase in sugar content and purity, or yield, after the last week in September.

The data for 1902 is especially interesting, showing the effects of the early freeze of September 12 of that year, which destroyed the leaves. This was followed in a week by a heavy rain amounting to six inches, causing the beets to put forth an entirely new set of leaves. The effect of the renewed growth is plainly seen in the great decrease of sugar content and purity reaching the minimum twenty days after the rain on October 10.

PRACTICAL SUGGESTIONS AS TO THE USE OF FERTILIZERS ON SUGAR BEETS IN COLORADO

The Kind to Use.—Nitrogen is the only element which has proven of practical value giving decided profit over the cost of application. Its use in the form of nitrate of soda with potash and phosphoric acid together in "complete" fertilizers, has not been as effective in increasing the yield, as nitrate used alone. On the contrary there are decided indications that the effect of the nitrate has been largely neutralized when so used, although the quality of the beet has been good.

Although nitrogen from nitrate of soda has been effective in increasing the yield, no sufficient comparaive tests have been made as to the effect of nitrogen from the less soluble organic fertilizers such as dried blood, tankage, or cottonseed meal. It is probable that the same amount of nitrogen from those sources would be less effective although this is offset to some extent by the fact that their cost is less and more could be used.

WHERE AND HOW TO USE NITRATE OF SODA

The Soil.—It is probable that nitrate of soda could not be used profitably on soil which is in condition to produce close to the maximum yields of the particular locality without manures or fertilizers. It also must be understood that fertilizers, no matter how effective, will never take the place of proper preparation of the soil and care of the crop. It is absolutely necessary that the soil be in good physical condition in order to enable plants to use the plant food therein, or added to it.

For our conditions the most satisfactory practice would probably be to use nitrate of soda along with a light coating of manure. The maximum effect of both would be secured in this way.

Depending upon conditions it will require a yield of sugar beets of from six to ten tons or more to cover cost of production. No land is likely to be planted to sugar beets which will not produce that much. The high average yields are in the neighborhood of twenty tons per acre. The profitable application of nitrogenous fertilizers then will probably be on soils which, without manure or fertilizers, will range in yield from ten to fifteen tons per acre.

ANY INJURIOUS EFFECTS OF NITRATE

The Beet.—Our Colorado soils and climate have shown an ability to produce a high quality of beet under good average conditions. The quality of the beet is also largely controlled by the proper irrigation. Manures are chiefly valuable for the large amount of nitrogen they contain, besides the humus, and it has been shown that even excessive quantities of manure will lower the sugar content only from one to two per cent, and purity two to four per cent. Excessive quantities of nitrate of soda will do the same, but neither is recommended. The presence of more active nitrogen than the plants can use lessens the yield.

It might be reasonable that as active nitrogen acts as a stimulant it will induce the plants to absorb so much of the other available elements in the increased crop, that there would be none left over for the next crop. Our soils contain ample supplies of both potash and phosphoric acid held in reserve, which are constantly being liberated or made available in the soil, and of lime we have something to spare.

It is claimed that nitrate of soda has a tendency to make the soil more compact or less easily workable. Even if such is the case, and it has not been observed in our experiments, it is difficult to see how

this could take place with the frequent cultivation and hoeings sugar beets are bound to receive. Granting that there is some truth in both claims advanced, the soil would have ample time to recover during the rotation with other crops, which is imperative for best all round results. It is well known that crops do not use the same amounts of food elements, and while growing they give an opportunity for those elements to accumulate which are best used by a succeeding different crop.

How Much to Use.—The limit of profitable application of nitrate of soda on land which is naturally capable of producing from ten to eighteen tons per acre is probably from 150 to 300 pounds per acre. The larger quantity gives more profit on less productive land than on more highly productive soil. This is largely due to the fact that there seems to be a certain limit to the productiveness of a soil, due more or less to its present physical state of condition, no matter how much available plant food is present.

In one case 580 pounds per acre applied to land which produced 11.5 tons without fertilization, gave a small profit, but not nearly as much in proportion as was derived from smaller amounts applied on the same land. In another case 300 pounds applied to a soil which produced twenty-eight tons per acre without fertilization increased the yield, while 100 pounds applied to the same soil, was without effect.

Larger quantities can sometime be applied, depending on the soil, with an increase in yield it is true, but the margin between the returns from the increased yield and the cost of the fertilizer, will not be as great as when smaller quantities are used on the same soil. A point will be reached where cost of the fertilizer applied will equal the increase in yield. And in the case of nitrate of soda an amount much beyond that point, will decrease the yield even below the normal productiveness of the soil.

WHEN AND HOW USED

Details of Application.—Cost.—No matter in what manner the nitrate is applied it must be prepared by breaking up the lumps and coarse particles and passed through a one-fourth or one-third inch sieve or screen. It can then be broadcasted before the last harrowing before seeding, which is probably the best method, or sown with the combined seeder and fertilizer drill with the seed. The broadcasting can be done with an endgate seeder or fertilizer sower, or with drills made for the purpose. When sowing the nitrate at the same time as the seed by the use of a fertilizer attachment to an ordinary beet seed drill, the writer has found that unless the material is kept agitated it is likely to "bridge" similar to beet seed, and stop feeding.

As to the cost of application it has been found that by the use of an endgate sower, two men with a team and wagon are able to cover from forty to fifty acres per day at an expense of $6.00 per day, or at forty acres per day, fifteen cents per acre. The screening of the nitrate and resacking should not exceed five cents per hundred.

With a fertilizer drill distributor with one man and a team, half that number of acres could probably be covered. When drilled with the seed the only duty would be to keep the hoppers or cans full and prevent 'bridging.'

SUMMARY AND CONCLUSIONS

(1) Our Colorado soils generally contain ample supplies of potash and phosphoric acid, and an excess of lime.

(2) The native soil is generally somewhat deficient in nitrogen and humus, both are supplied by growing leguminous plants like alfalfa, peas, vetches, or beans, or from sheep and stable manures. Nitrogen, but not humus, can be supplied by commercial fertilizers.

(3) Nitrogen in the form of nitrate of soda is the only element which has had any decided effect in increasing the yield of sugar beets over the cost of application.

(4) Potash and phosphoric acid, from sulphate of potash, raw bone meal, Basic slag, dissolved or acid bone, and phosfate rock, used alone or together, have very little or no effect upon the yield.

(5) There are strong indications that potash and phosphoric acid from fertilizers, largely, if not entirely, neutralize the effect of nitrate of soda upon the yield of sugar beets, although the quality of the beet is good.

(6) No difference in results were obtained between applying the nitrate of soda at the time of planting, or in part at the time of planting, and in two applications during the growing season.

(7) The net profit from reasonable quantities of manure, if cost of manure and its application is considerable, is mainly obtained in the after effects in the succeeding year, while there appears to be no residual effect the third year after application.

(8) An excess of nitrogen from manures or fertilizers over what the plant needs lowers the yield and the quality of the sugar beet some though not much.

(9) Reasonable quantities of manure were fully as effective as large or excessive quantities.

(10) Refuse lime cake from the sugar factories as a fertilizer on sugar beets was of no benefit.

11() Soluble fertilizers applied to the seed favored strong germination.

(12) Very high sugar content and purity seem to go with low yields, although there are exceptions.

(13) Fertilizers will not take the place of good preparation or cultivation of the soil, or good care of the crop. The soil must be in good physical condition to make the best use of fertilizers applied.

(14) The tops were about forty-four per cent of the weight of the clean beets. A fifteen ton crop of sugar beets will produce 6.6 tons fresh, green tops. It is estimated that this will air-dry to one-eighth the original weight or 0.8 of a ton.

Bulletin 116 June, 1906

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

THE COTTONY MAPLE SCALE

By

S. A. JOHNSON

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THE AGRICULTURAL EXPERIMENT STATION

FORT COLLINS, COLORADO

The Cottony Maple Scale

Pulvinaria innumerabilis Rathvon.

BY S. ARTHUR JOHNSON.

The past few years have witnessed a recurrence of the cottony maple scale in injurious numbers in several parts of the United States. The present outbreak has brought about a greater activity in the use of remedial measures than ever before, and though the control of the insect has not yet been accomplished, sufficient has been learned to point the way. It is the purpose of this bulletin to gather the important points of economic literature and the series of experiments and observations made at this station so that what is now widely scattered may be immediately available to those who need the information.

The most bitter complaints of injury at all times appear to have come from places where the maple tree is cultivated for shade. The reasons for this are not positively known, but we are tempted to speculate that it is due to the artificial conditions under which the trees are placed. Under forest conditions the insect appears to be kept in check by its natural enemies, which doubtless, find shelter and protection in their native haunts which are denied them among trees planted on private grounds and in parks.

Thus far the remedies and their application are rather expensive, but are amply justified when we consider that a beautiful tree is the work of years and cannot readily be replaced except by a repetition of the long years of waiting.

SYNONOMY

Riley in the report of the Commissioner of Agriculture for 1884, has summarized the synonomy of the species to that date and to that article I am chiefly indebted for this paragraph. The insect was first described as *Coccus innumerabilis* by Dr. S. S. Rathvon of Lancaster, Pa., in the "Pennsylvania Farm Journal" (Vol. IV, pp. 256-258, Aug., 1854.) Five years later, Dr. Asa Fitch redescribed it in the "Transactions of the New York State Agricultural Society" (Vol. XIX, pp. 775-776) under the name of *Lecanium acericorticis*. A third description was made by Walsh and Riley in the American Entomologist (Vol. I, p. 14, 1869) as *Lecanium acericola*, the previous descriptions having been overlooked. A closely allied form on the osage orange, received from these last writers the name *L. maclurœ*. After the publication of the names given by Riley and Walsh, Dr. Rathvon called the attention of these entomologists to his description and subsequent

correspondence showed that the species were identical. Glover in 1877 revived Fitch's name of *Lecanium acericorticis* which had been overlooked up to that time.

While this portion of the problem of synonomy was being thrashed out, Mr. J. Duncan Putnam was making a careful study of the life history. Four articles came from his pen. The first three were printed under Walsh and Riley's name of *Lecanium acericola.* (*). The fourth article is a very thorough study of the life history covering some fifty pages of text and accompanied by two plates. (**). In it the author, at the suggestion of Prof. Riley, restored the original name of *innumerabilis* and transferred the species to the genus *Pulvinaria.*

While this discussion appeared to clear the field to the point given it was far from doing so. It appears that Walsh and Riley, Putnam and other writers had collectively confused at least three distinct species. This state of affairs was discovered by Dr. Howard and unraveled by him in 1900. (***). In their original article Walsh and Riley had really included two species in both the cut and description; one in which the female reached the adult stage on the twigs and corresponds to *P. innumerabilis* Rathv., and a second which matures on the leaves and receives the name *P. acericola* W. & R. A third form, *P. macluræ* occurring on osage orange had been considered synonymous with *P. innumerabilis* by some writers. Prof. Cockerell has since examined this and considers it entirely distinct. To the western form the latter writer has given the varietal name of *occidentalis.* If this should prove to be a distinct species it will raise again the question of its introduction. Some of the scales found on food plants widely separated from maple may yet be found to be distinct from *P. innumerabilis.*

DISTRIBUTION

This insect is a native of the United States and our literature dates from its discovery by Dr. S. S. Rathvon in Pennsylvania. It has, however, long been widely distributed over the country. (See Fig. 1.) Mr. Sanders calls attention to the fact that the insect is preeminently an inhabitant of the upper austral zone, though sometimes it penetrates the transitional. In other words it is found in the middle zone of states extending from the Atlantic coast to the Rocky mountains. Outside of this range it is found northward in New York, Michigan and Wisconsin. To the south, branches appear to follow the highlands into Tennessee, Georgia and North Carolina and at the western extremity into Texas. Mr. Gossard found it on pecans in Florida, where in some cases, it was doing considerable injury. In the western states the pest is reported from Washington, Oregon, Idaho and California (both northern and southern) where it is believed to be an introduced insect.

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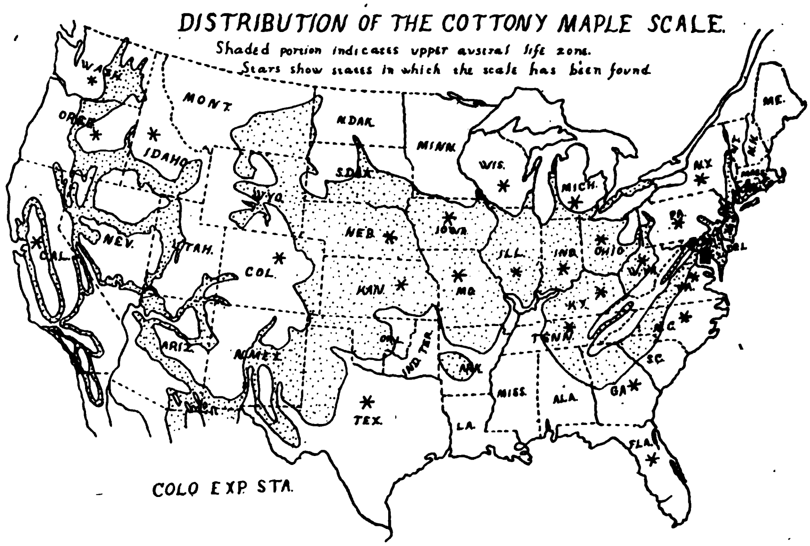
*(Prof. Davenport Academy of Nat. Sci., Vol. I., p. 37, 1876; Davenport Daily Gazette, June 5, 1877; Trans. Iowa Horticultural Soc., 1877, pp. 317-324.)

**(Proceedings Davenport Acad. Nat. Sci., Vol. II, Part V., pp. 297-347, 1879.)

***(U. S. Dept. Agr. Division of Entomology, Bul. 22, n. s.)



FOOD PLANTS

The host plants of this species are very widely distributed among trees, shrubs and vines. Sanders states that the list comprises forty-seven varieties and species. But few of these are of economic importance for they are seldom badly infested. The greatest sufferer is the food plant from which the insect receives its name, the soft or silver leaved maple (*Acer saccarinum*). Next in importance are the box elder (*Acer negundo*), black locust and elm. It has also been found in large numbers on pawpaw in Illinois. Mr. H. E. Weed gives as less seriously affected, linden (*Telia*), Virginia creeper (*Ampelopsis quinquifolia*), bittersweet (*Celastrus scandens*), sumac (*Rhus*), grape (*Vitis*), and willow. Together with some of the above, other writers have mentioned poplar, beech, hawthorne, sycamore, hackberry, mulberry, poison ivy, rose, basswood, and ash. In Georgia the oak is reported as being seriously affected. Singularly, sugar and Norway maples seem to be but little injured even where they are surrounded by badly infested host plants.

Among fruit trees, the pear is the greatest sufferer. Apple, plum, peach, currant and gooseberry are also sometimes attacked.

Some plants serve as hosts during the summer, but do not appear to winter over the insect. A list given by Mr. Weed includes *Spiræa Van Houtenii*, *S. arguta*, *S. prunifolia*, *Philadelphus grandifloris*, *P. coronarius*, *Cornus mascula*, *C. siberica*, *C. stolonifera*, *Ribes aureum*, *R. sanguinium*, *Hydrangea*, *Rudbeckia*, *Syringa* and *Vibernum*.

The western form, which is known as *occidentalis*, appears to be fastidious in its tastes or has imbibed the western spirit of a desire

for new things, for Mr. Piper states that it is not found abundantly on the native maples, but infests currant, gooseberry, plum, pear, hawthorne, mountain ash, Lombardy poplar, weeping willow, currants (*Ribes sanguinum*), and species of willow (*Salix flavescens* and *S. lanadra*).

A careful study of the forms on all of these food plants has not been made and it will be wise to make a mental reservation as to the identity of the species in some cases until further evidence is forthcoming.

The economic history of the insect shows that its destructive abundance in certain localities is periodic. The data at hand fail to show that this periodicity is amenable to any law, though there have been two periods of general abundance over its range. The statement has been widely circulated that the scale is seldom injuriously abundant two years in succession, but this has been proved to be untrue within the past few years in widely separated localities. In the early eighties there was a general visitation of the pest and Dr. Forbes made a number of preliminary experiments looking toward control. On this occasion the insects appeared in great abundance in 1880 and 1884, subsiding to insignificant numbers during the intervening years. A second scourge occurred during the past five years and is reported by Mr. Chittenden as being more generally abundant over its range than at any previous year. The city parks of Denver and Chicago seem to be the storm centers. In the latter place the lower limbs of the silver maples have been killed in great numbers, leaving the trees unshapely in appearance. Many hundreds of trees have been killed outright. In Denver the destruction has been, perhaps, less severe, but weeks were spent cleaning dead limbs out of the parks and many trees along the more crowded streets have been injured to such an extent that they are practically worthless.

LIFE HISTORY

When the sap begins to flow in the food plant the young hibernating females begin to suck up the fluid rapidly and to grow. In a few weeks they have increased their size about four times. At this stage the scales, which before may have been unnoticed because of their flat position on the bark and similarity to it in color, become suddenly conspicuous on account of the white cottony mass of wax which is thrust out from under the posterior end. This material is, composed of wax threads spun from the ventral glands of the animal, especially those located on the margins, and serves as an ovisac. (See Fig. 2.) The quantity is enormous for the size of the insect. The extrusion of it gradually raises her body from its flat position on the twig until it stands out at an angle of some sixty degrees or even vertically. During this period the egg laying proceeds. This takes place at different times in different localities and seasons, varying with the temperature and in some cases with the food plants. In Florida when this scale appears on pecans, Gossard states that the ovisacs become conspicuous during April and May. In most other places they appear in May or June.

The egg laying extends over almost the entire period of cotton secretion, but is most active during June. In many cases it doubtless begins in May and extends, in some cases at least, into July.

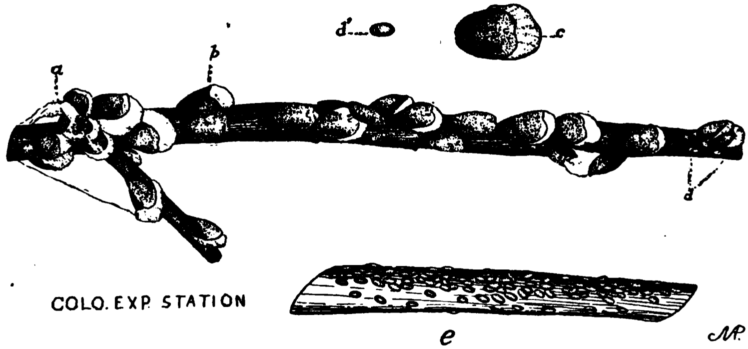


FIG. 2. Females of the cottony maple scale: a, ovisac opened to show eggs; b, females with cottony mass partly secreted; c, slightly enlarged female; d, parasitized winter form; d' the same slightly enlarged; e, hibernating winter form. All except c and d' natural size. (Drawn by Miss M. A. Palmer).

The eggs are tiny oval spheroids, pale cream in color. The number as given by the older entomologists is from one to two thousand. These figures are probably somewhat too large and more recent writers have reduced the estimate. Cotton mentions from three hundred to one thousand and Sanders says that the number may reach fifteen hundred.

The egg hatching likewise consumes considerable time. To quote from Dr. Howard on observations made in Washington, D. C.:

"The young lice hatch early in summer, usually in June, but occassionally at least as early as May 22. The hatching period usually extends on into early July, but may last until August."

Seasonal influences appear to bear considerable weight. Mr. H. E. Weed makes the following note of conditions in Chicago in 1904:

"During the past summer the eggs were slow in hatching, as the season was very backward. Up to June 25, practically no eggs were hatched. Two quite warm days occurred about July 10, and this served to bring them out."

In the visitation of 1884, Dr. Forbes states that the young were abundant by the middle of June, but in some localities 25 per cent of the eggs were not hatched on July 19. Colorado observations give the following: "June 22, 1901. Scales from Delta and Montrose were full of eggs, but no lice hatching yet." "July 2, 1902. All hatched and beginning to scatter from twigs of soft maple from Colorado Springs." "Denver, June 10, 1904. The scales are just beginning to raise and expose the cottony secretion of the louse. I find on examining these scales that a few eggs have already been deposited." The foregoing notes were made by Prof. Gillette.

On July 15, 1905, I visited the parks of Denver and found that most of the eggs had already hatched. In fact, unhatched clusters were very difficult to find. There appears to be an unexplained phenomena in that the eggs laid on some trees hatch at times differing

from their neighbors. Young lice have been known to appear upon box elder before maple.

The newly hatched young remain a day or two in the ovisac and then migrate to the leaves where they attach themselves to the ribs or, rarely, to the young twigs. In doing this they prefer the under sides and larvæ so situated appear to grow more rapidly than those otherwise located. In times of serious infestation these locations soon become preempted and the young swarm over every green thing within a short radius of their home. It is in these cases that the summer food plants serve as hosts. On some of these they seem to prosper fairly well. Dr. Forbes found that the males reached maturity on strawberry plants, and, as an isolated maple tree which had been thoroughly treated during the summer was reinfested in the fall, concluded that the females had found their way back from temporary food plants.

Shortly after the young begin to feed a delicate waxy scale forms over the back.

The first molt occurs in from three to four weeks from the hatching of the egg. It was observed in Washington as early as June 10. At this time the insects are about twice their size at hatching.

After this molt the differences in the sexes is observable. "The males grow more slender and soon cease to increase in size, covering themselves with a thin coating of wax." At this stage, according to Howard, the second molt takes place beneath the scale and a propupal stage occurs. (See Fig. 3.)

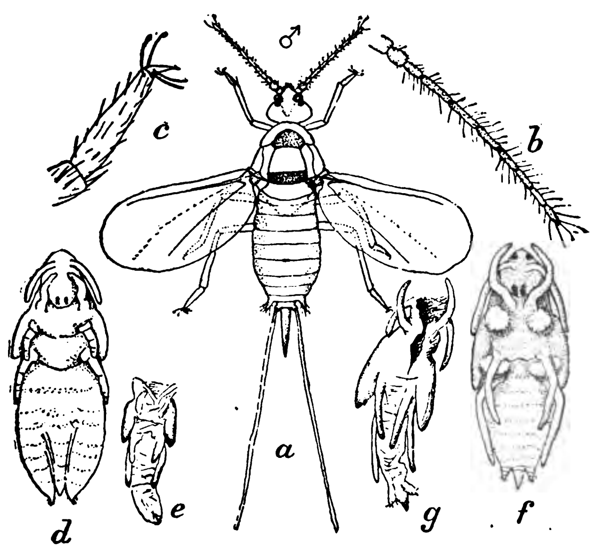


FIG. 3. PULVINARIA IMMUMERABILIS: a, adult male; b, antennæ of same; c, leg of same; d, second stage of pupa; e, cast skin of same; f. true pupa; g, cast skin of same All greatly enlarged, b and c still more enlarged. (Howard Bul. 22, Div. of Entom., U. S. Dept. Agr.)

"In a few days the pupa casts its skin and assumes the true pupa form, which, during its earlier stages is a pale green color, becoming dark flesh color at a later date." "The antennæ which up to this time were seven-jointed, had now become eight-jointed. There seemed to be two propupa stages. After casting the second skin,

the male larvæ looses its rostrum and its anal cleft, although the wing pads have not yet developed; the antennæ are stout and laid backward without perceptible joints, and that end of the body is furnished with two long conical tuberculæ. After the third skin is cast, an apparent propupal stage is found which bears wing pads reaching to the abdomen; the claw of the tibia is lost, and between the posterior tubercles has appeared a stout, rudimentary style."—Howard. "A long pair of wax filaments is secreted from the anal extremity and these continue to grow during the life of the insect. It is the protrusion of these filaments from beneath the waxy scale which indicates the approaching exclusion of the male."—Riley.

The changes in the female scales are less conspicuous but nevertheless characteristic. After the first molt they broaden posteriorly and have a slight dorsal carina. When the males appear, they have undergone a second molt and changed from pale yellow to light green and are marked with a brown dorsal stripe the whole length of the body.

The males appear during the latter part of August or first of September, copulate with the females in a few days and die.

The summer injuries are most conspicuous on the leaves. Dr. Forbes states that in 1884 many trees at Bloomington, Ill., had lost a considerable portion of their leaves by August 16, and the others were blackened and dwarfed, giving the branches a bare and unthrifty look.

In early October the gravid females desert the leaves and find places for hibernation on the branches and twigs. Immense numbers drop to the ground with the falling leaves which results in a great loss of life from the inability of many to find their way back. The position sought is the under sides of the twigs and small branches, the lower branches of the tree being usually most densely populated. Many locate around the crotches and on the upper sides of the twigs. The scales are still quite flat and about one fourth grown, varying from one and one half to two and one half millimeters in length. The position assumed on the twig is more often lengthwise than crosswise and the number may be as great as the bark will accomodate. (See Fig. 2 e.) The color changes at this time from a light green to light brown. It is very doubtful if any nourishment is taken from this time till the spring activities begin. The mortality, outside of parasitism, during this period is considerable and varies greatly with different twigs and trees. The check twigs counted from trees in Denver showed this to vary from twenty-five to sixty-two per cent.

SPREAD OF THE INSECT

But few instances of the transportation of the insect have been observed, and these are of such a nature as to account for but a small portion of the infestation. The most fruitful source in the past has doubtless been through the transplanting of trees, for this is done when the insect is firmly attached in the hibernating stage. Over short distances they may be transported on the feet of birds or clinging to the parts of insects. The eggs hatch during summer when there is little migration among birds so that great distances are probably not made in this way. It is not probable that many migrations of this kind arc made in the fall when the insect is moving from the leaves to the twigs, since the insects at this time are probably too large to be readily carried by these means. Either the newly hatched young or gravid females may be transferred from tree to tree by the interlocking of limbs or by

first falling to the ground. Prof. Garman found a goldfinch's nest covered on the outside with nests of *Pulvinaria.* Mr. Hubbard believed that spiders were the chief means of transportation.

ENEMIES

As might be expected, the cottony maple scale, being a native insect, is preyed upon by a wide range of enemies which includes both those which prey upon insects in general, and the groups which confine themselves to a smaller range of hosts.

The only instance of a vertebrate being among the group was observed by Dr. Howard, when he saw an English sparrow eating the waxy masses in Washington. That these birds do not offer much hope of relief is evident when we remember that the most serious outbreaks of the pest have occurred in those places where this sparrow is most abundant.

The *Arachnida* have come to the rescue but once and that was when the harvest mites were found by Miss Murtfeldt feeding upon the eggs in Missouri.

The larvæ of a species of lace winged flies (*Chrysopa*) and two species of assassin bugs (*Reduviidæ*) were found by Mr. Putnam to feed upon the scales. In Denver, the nymphs of what Mr. Ashmead has determined as *Corizus hyalinus* were found working among the egg masses.

Probably more important than any of the foregoing are the ever faithful ladybirds. *Chilochorus bivulnerus* during all stages of its life, but especially while young, feeds upon this insect. Several species of *Hyperaspis* notably *H. signata, H. bigeminata* and *H. binotata* do good service, while to these must be added *Rhizobius ventralis.*

The larvæ of a species of small moth, described by Prof. Comstock (*) as *Dakruma* (*Lœtilia*) *coccidivora* did very effective service in Washington, D. C. According to Dr. Howard:

"This caterpillar flourished upon the twigs upon which the scales were closely massed together, and ate its way through the mass from one scale to another, spinning a close rather dense web as it progressed. Each caterpillar in this way destroyed very many scale insects. The writer has always thought that it was due to this insect alone that the cottony cushion scale almost disappeared from the Washington shade trees in the close of 1879, and was never seen here again until, in the summer of 1898, nineteen years later, it became once more rather conspicuous, although by no means as abundant as in the former year. The *Dakruma* not only destroys the old wornout female, but devours her eggs and young larvæ with avidity. The caterpillars are very active, moving about freely within their silken passages. They were to be found full grown on June 24, spun their cocoons within the silken tunnel, and remained ten days in the pupal state. The moths issued from July 17 to August 13, soon thereafter ovipositing and laying their eggs, which hatched in six days. Whether another generation of moths issues the same year has not been determined."

Prof. Riley states that in Florida this larvæ attacks "a large *Lecanium* on magnolia, a coccid allied to *Dactylopius* and the common "turtle back scale."

But the credit for the most effective work of eradication of the cottony maple scale is due after all to the chalcid parasites. The general insect enemies are helpful at all times, and in some cases become quite important, the *Dakruma* larvæ have been locally beneficial,

(*) Report Dept. Agr., 1879, 241-243.

but the scale is never able to withstand the onslaught of the chalcid parasites. The most important of these is *Coccophagus lecanii* Fitch This minute parasite was reared by Putnam during his study of the insect and appeared in Washington, D. C., in such numbers in 1898 as to interrupt the experiments of Dr. Howard. It is very widely distributed and has been reared from other scales of the Lecanine group. The adult is a minute, black four-winged fly, marked with a crescent shaped yellow patch in the middle of the body above. Dr. Howard states that less than one per cent of the larvæ which settled upon the leaves under his observation escaped destruction by this parasite. The scales were stung during midsummer. They afterward turned black and the parasites emerged through holes out of their backs. The development of the parasite was very rapid, not occupying more than two or three weeks. Mr. Putnam believed that there were two generations, but Dr. Howard thinks that there may be many more. Closely allied to this species is *C. flavoscutellum* which does for the southern range of the scale the work accomplished in the north by *C. lecanis.* Its range, however, is not confined to the south for it has been reared by the writer from scales taken in Denver.

The other chalcid parasites appear to be of less importance. *Comys fusca* Howard is a common parasite on Lecanine scales and widely distributed. *Aphycus pulvinariæ* Howard was reared by Mr. Putnam, and *Atropates collini* Howard was bred in both 1889 and 1891 by Dr. Howard from females of the cottony maple scale from Brooklyn and Roslyn, N. Y. *Eunotus lividus* Ashmead has been reared in March and April from old scales, the parasites spinning clusters of stout cocoons under the bodies of the old scales. Specimens were reared by the writer from egg masses taken in Denver during July. (See Fig. 4.) In each case, however, there was but one cocoon under each scale. Specimens of *Cheiloneurus albicornis* have been found in our breeding cages.

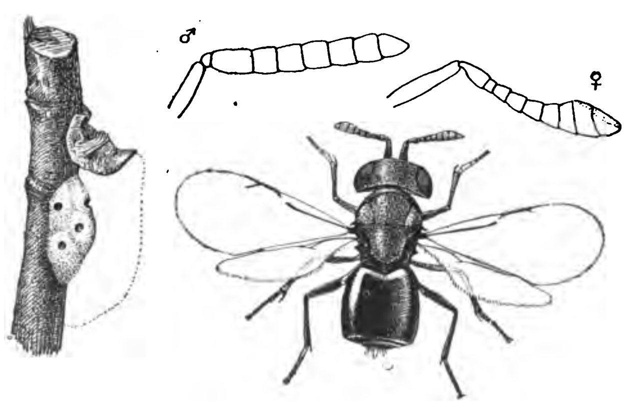


FIG. 4. EUNOTUS LIVIDUS, greatly enlarged, with male and female antennæ above—still more enlarged. (Howard Bul. 22. Div. of Entom., U. S. Dept. Agr.)

REMEDIES

The history of the remedies is very brief owing to the fact that

the insect has not often been a serious pest in any one locality long enough for the problem to be worked out.

Summer Treatment.—In 1884 Dr. Forbes made a number of preliminary laboratory experiments on the effect of insecticides on young lice. A leaf dipped in 2½ per cent kerosene emulsion showed that the lice were killed. A branch treated in the same way showed a mortality of three-fourths in twenty-four hours. A branch sprayed with the same preparation showed one-half dead after four days. A branch dipped in five per cent solution killed all. Whale oil soap appeared to be less satisfactory for the larvæ were not all killed with a solution weaker than one pound to two gallons, and these strengths all did greater or less injury to the foliage.

In the summer of 1904, Mr. H. E. Weed did considerable spraying in the parks of Chicago. The work began in the middle of July and extended to the first of September. Kerosene emulsion of eight or ten per cent strength was used at first, but afterward increased until fifteen per cent was reached. The results I give in his own words:

"Practically none of the insects were killed with either the eight or ten per cent emulsions. An examination at Prof. Forbes' office of leaves sprayed with 12½ per cent some days after showed that something over fifty per cent were killed but the death of some of these was doubtless due to natural causes. The fifteen per cent emulsion killed the greater portion of the *Pulvinaria*, but as this strength took practically all of the leaves off the boxelder, all from the lindens and fully one-half from the maples, the remedy was at least equal to the disease."

The failure of these later treatments compared with those of Dr. Forbes is doubtless due to the age of the young scales. It is probable that the greater portion of the young larvæ were protected by waxy excretions of considerable thickness by the middle of July. From experiments which are described below I am convinced that the newly hatched larvæ are very easily killed. Kerosene emulsion as low as five per cent and Good's whale oil soap as weak as one pound to four gallons appeared to be entirely effective.

From the foregoing it must appear that a summer spray for the young scales alone must be a very protracted and expensive task. It is probable that a weak spray will not be effective on a scale more than a week or ten days old. The greater portion of the eggs hatch probably between the middle of June and the first of August. This would necessitate from four to six very thorough treatments to greatly reduce the numbers, even granting that all of the lice may be reached by each spray, a condition which anyone who has had very much practical experience would hesitate to admit.

In the summer of 1904, the writer made a number of preliminary experiments for the purpose of pointing the way to a summer treatment. Since these have not been published before they are given in full. The first eleven were treated on July 3, and the others on July 5. The examinations were all made on July 14, and eggs which appeared to be alive in Nos. 4, 5, 10, and 16 were isolated and examined July 26.

TABULATED STATEMENT OF TESTS WITH INSECTICIDES

EXP.	CONDITIONS.	INSECTICIDE	RESULTS
1	Large scale full of unhatched eggs. Some larvæ running about.	Ker. Emul. 50% kerosene	Everything soaked with oil and dead.

TABULATED STATEMENT OF TESTS WITH INSECTICIDES (CONTINUED)

EXP.	CONDITIONS	INSECTICIDE	RESULTS
2	Four large scales. Eggs and larvæ.	Ker Emul. 33 1-3% kerosene	Everything soaked with oil and dead
3	Several large females. Eggs and larvæ.	Do. 25%	Everything appears to be dead.
4	Mass of females. Eggs and larvæ.	Do. 20%	Emulsion penetrated well. A few eggs under one scale appeared to be alive, but failed to hatch by VII, 26.
5	Isolated females. Eggs and larvæ.	Do. 15%	Larvæ and most eggs dead. Two scales had fresh eggs under them, some of which had hatched by VII, 26.
6	Isolated large female	Do. 10%	Larvæ reached are dead. Emulsion did not penetrate. Abundance of eggs and larvæ in center of masses.
7	Clustered females. Well protected eggs and larvæ.	Do. 5%	Exposed larvæ and eggs under smaller scales all dead. Large masses with many young.
8	Scattered females.	Tak-a-nap, 1 ℔ to 1 gal. water.	Penetrated and killed well. Two live lice under one scale.
9	Large masses.	Do., 1 ℔ to 1½ gal. water	Everything appears to be dead.
10	Masses of females and eggs.	Do., 1 ℔ to 2 gal water.	Everything dead except possibly one large mass. Eggs did not hatch by VII, 26.
11	Isolated females.	Do. 1 ℔ to 3 gal. water.	Penetrated well. Everything dead.
13	Isolated scales. Not large.	Good's whale oil soap, 1 ℔ to 1½ gal. water.	Eggs and larvæ all killed.
14	Many females, larvæ and eggs.	Do. 1 ℔. to 2 gal water.	Masses penetrated and everything killed.
15	Do.	Do. 1 ℔. to 3 gal water.	Everything exposed, dead. A few live larvæ under two scales.
16	Clustered females.	Do. 1 ℔. to 4 gal. water.	Eggs and larvæ killed where reached. Penetration poor. Eggs from center masses hatched by VII, 26.

The preparations were applied in the laboratory by means of an atomizer. An examination of the table shows that eggs and newly hatched larvæ are easily killed even with the weakest strengths used. The point of difficulty is to secure a treatment which will penetrate the cottony masses. The experiments must be considered indicative at best, but they show that kerosene emulsion twenty per cent or more in strength, and the soaps at the rate of one pound to two gallons or stronger, will probably be effective. These insecticides cannot, of course, be used as a spray on the foliage. It will be necessary to apply them by means of a sponge or brush.

To Sum Up.—Summer treatments in practical experience have proved a disappointment, and must be considered a makeshift at best. If they become necessary, it will be better to combine two methods. As soon as the cottony masses appear, or certainly before the eggs have hatched in large numbers, trim out and promptly burn the infested twigs and such limbs as may be removed without seriously marring the appearance of the tree. The remaining masses should then be thoroughly soaked with a strong kerosene emulsion or soap solution not less than one pound to two gallons in strength, the insecticides being applied with a brush or sponge.

Winter Treatment.—During 1903 and 1904 the writer conducted a series of experiments in the parks of Denver under the direction of Prof. Gillette, and with the consent and assistance of the park authorities. Since these were published in detail with the Proceedings of the Association of Economic Entomologists (Bu. of Entom. Bul. 52) they will be but briefly reviewed here.

Preliminary laboratory experiments conducted during January, 1903, in which lime sulfur salt, kerosene emulsion, and hard whale oil soap were used showed little or no benefit from the first substance. Kerosene emulsion killed satisfactorily when twenty-five or more per cent in strength. The next application was twelve and one half per cent in strength and did not seem to be effective. Hard whale oil soap one pound to one gallon worked well, killing all exposed scales. The weaker strengths did not show an appreciable value. These experiments were repeated a week later, with practically the same results, except that the whale oil soap did not furnish such favorable data.

The following winter two series of experiments were conducted in Curtis park, Denver. In the first, kerosene emulsion killed satisfactorily as low as twelve and one half per cent kerosene. Tobacco stem decoctions were entirely inefficient. Bowker's tree soap at two pounds to one gallon shriveled the scales; at one pound to two gallons, killed two-thirds. Much to my regret, the test of one pound to one gallon was overlooked in checking up. This was unfortunate because this insecticide promised to be more useful than any of the soaps previously used.

In the second series, kerosene emulsion again killed as high as ninety-four per cent when only twelve per cent kerosene in strength. Lime sulfur salt was again a total failure. Hard whale oil soap at one pound to one gallon killed ninety-eight per cent of the scales.

As a result of this work kerosene emulsion, one-sixth kerosene, was

recommended and used in the parks of Denver. In July, 1905, I carefully examined Fuller park which had been treated in this way and was surprised to find it clean. Not more than a dozen of the cottony masses were to be found and there were practically no scales on the leaves. A reexamination of the same park in January, 1906, however, showed that almost every tree was infested with a few scattering females, which proved, I think, that the eradication of the scale is a practical impossiblity.

The climate of Denver is much drier than that found in most parts of the insect's range. The last set of experiments, however, were conducted during a wet period, but the results did not appear to be seriously affected. Mr. Braucher writes me that kerosene emulsion has been used in the Chicago parks about twenty per cent in strength with most excellent results.

The winter treatment is the ideal one from a number of considerations. The insects are more easily reached, for the twigs and limbs are exposed. Insecticides may be used in sufficient strength to kill without injury to the tree. The hibernating females are generally on the under sides of the limbs and most abundant on the lower branches, which makes the application more easy. The amount of insecticide required is less than half what it would be in summer.

To Summarize.—The cottony maple scale may be controlled by a winter treatment of kerosene emulsion fifteen per cent or greater in strength, and probably by whale oil soap at the rate of one pound to one gallon. It may be necessary to use a higher percentage of kerosene where the climatic conditions are unfavorable. Eradication of the scale is not to be expected and only such trees and areas should be treated as are threatened with serious injury.

Too great stress cannot be laid on the thoroughness of the work. The tree should be treated from both sides and from beneath each limb. After treatment each tree should be carefully inspected and the missed spots "touched up."

The kerosene emulsion should be carefully made. It is better to use more soap than the ordinary formula, since soaps vary somewhat in emulsifying powers and the satisfaction of a good emulsion more than repays the slight extra cost. During 1906, the Denver park authorities used in part a soft naptha soap. Twigs which had been treated with this emulsion were sent to this office and examination showed all the insects to be dead.

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Press Bulletin No. 24. February, 1906.

The Agricultural Experiment Station,
Fort Collins, Colorado.

FORMALIN TREATMENT OF SEED GRAIN FOR SMUT.*

By W. H. OLIN and F. KNORR.

The prevalence of smut in wheat and oats in Colorado calls for earnest work on the part of grain growers of our state to check its ravages and stamp out this most pernicious plant disease.

WHAT IS SMUT?

It is a parasitic fungus which feeds upon another plant as its host. It springs from a spore which corresponds to a seed in higher plants. This germinates when the grain is seeded and, penetrating the little grain plant when but a few days old, grows up within the grain stem. After entering the stem there is no evidence of its presence until the grain begins to head. At this time the smut plant robs the developing kernels of their nourishment and ripen a mass of smut spores.

HOW THE GRAIN IS INFECTED.

These spores usually ripen before the grain does and are blown about the field, many spores becoming lodged on the ripening grain kernels. The wholesale agent of infection however, is the threshing machine; the crop from a field practically free from smut is therefore liable to infection by spores carried by the thresher from some infected field. For this reason the safest plan is to *treat all your seed wheat and oats each year.*

METHOD OF TREATMENT.

First. Secure from your druggist a sufficient amount of formalin to treat your seed oats and wheat. Formalin is the

*Bulletin 79 (1903), by Jos. Reed, gives some experimental tests of various methods of treating stinking smut in wheat.

commercial name for formaldahyde gas held in a water solution. This gas should be a 40 per cent solution since this strength is necessary to kill the smut spores. It requires just about one ounce for every five bushels of grain to be treated.

Second. Clean off a space on the barn floor or sweep a clean space on the hard level ground and lay a good sized canvas down, on which to spread out the wheat. See that the place where the grain is to be treated is swept clean and thoroughly sprinkled with the formalin solution before placing the seed grain there.

Third. Now spread out your seed grain on the space prepared for treating it and prepare the formalin solution. This formalin is quite volatile so the solution should not be made until one is ready to use it.

Fourth. Use 1 ounce of formalin to every 2¼ to 2½ gallons, 4 ounces for 10 gallons, 16 ounces (one pound) for 40 gallons of water. Put the solution in a barrel or tub, thoroughly mixing it so the formalin will be well distributed. One pound of formalin to 40 gallons of water is sufficient to treat 2,500 pounds of grain.

For smaller amounts, estimate 6 to 8 quarts (1¾ to 2 gallons) of the solution for every 100 pounds of grain. This solution can be applied with the garden sprinkler. Care must be taken to thoroughly moisten the grain. Sprinkle, stir the grain up thoroughly and sprinkle again, until you feel certain every kernel is wet with the solution.

When you have completed the sprinkling process, place the grain in a conical pile and cover with horse blankets, gunny sacks, etc. The smut that does the damage lies just under the glume of the oats or on the basal hairs of the wheat. Covering the treated grain holds the gas from the formalin *within* the pile, where it comes in contact with the kernels, killing such smut spores as may have survived the previous treatment. After the grain has remained in a covered pile 2 to 4 hours, spread it out again where the wind can blow over it, to air and dry as rapidly as possible.

As soon as one can take the grain in the hand without the kernels sticking together, it can be sown in the field. Of course the grain is moist and therefore the kernels are enlarged so we will need to set the seeder accordingly. One can treat the grain in the forenoon and seed it in the afternoon.

Since this treatment swells the kernels it hastens germination and should be done in the spring just before seeding time. The treatment is practically inexpensive, takes but a few hours to treat a considerable quantity of grain and effectually kills smut when properly and thoroughly done.

While the copper sulphate or blue stone treatment is valuable in killing smut, the formalin treatment can be given in less time, is applied so easily and is so effectual that it is recommended as a sure and ready means of killing smut in wheat and oats.

Press Bulletin No. 25, February, 1906

The Agricultural Experiment Station

FORT COLLINS, COLORADO

INSTRUCTION FOR CO-OPERATIVE TREE PLANTERS

BY B. O. LONGYEAR

In Press Bulletin No. 22, A Co-operative Experiment in Tree Planting, brief directions were given for the planting and care of a tree-plantation for timber purposes. This leaflet has been prepared with the purpose of giving more detailed instructions to those with whom the station is about to undertake the co-operative tree planting experiments, outlined in the above press bulletin, and, in addition, it is intended to be of service to any persons who contemplate the growing of trees for utility purposes on their own account in this state.

The wide range in conditions of soil and climate which our state possesses makes it impossible to formulate any set of rules that will be suitable for all places or for any and all species of trees that might be planted for utility purposes. We have, moreover, but little exact data from actual experience of tree planters in this state to aid in this matter and must, therefore, depend largely on generally established principles in tree culture as well as the results of such practices in neighboring states. It should be further borne in mind that the following directions apply more particularly to the growing of the hardy or western catalpa and the common, yellow or black locust, which have been selected for our co-operative experiments in tree planting.

Location and Soil—The location of the tree plantation will be left largely in the hands of the owner of the land and may be made a matter of convenience providing suitable soil and irrigating facilities are available. On the plains, where the natural water supply is the only available one, the lay of the land may in some cases make it possible to set the trees where they will benefit by the surface flow from higher ground.

The soil should be such as is adapted to the growing of agricultural crops. While it might in some instances be possible to secure a growth of trees on poor soils and with a meagre supply of water, the purpose is to secure as rapid and productive results as possible and this cannot be accomplished on unproductive soils. Neither should a soil strongly impregnated with alkali be selected for this purpose nor such as are subjected to much seepage nor frequent overflow.

The soil should be well prepared by deep ploughing in the fall,

if possible, followed by thorough harrowing in the spring. If done in spring the ploughing should not usually be as deep as that in the fall, especially if the soil is a stiff clay or adobe as it does not work down easily but is apt to contain large air spaces unfavorable to the growth of roots of plants. Sandy soils are better prepared by deep ploughing at all times. Soil which has been in cultivation for one or more seasons is usually in better condition for tree planting than new soils and requires less work to prepare. In any case the preparation of the soil should be such as would adapt it to the growing of sugar beets, corn or wheat. It is not desirable to manure the land intended for trees unless it is done one year before the trees are set, thus allowing time for thorough decomposing.

PLANTING THE TREES

Spacing—The trees grown for utility purposes are to be planted in rows so that thorough cultivation can be given. The spaces between the rows and between the trees in the row must vary somewhat according to the conditions. Thus on land that is supplied with plenty of moisture throughout the growing season the trees may be set more thickly than on the plains where no irrigation can be given. The spacing decided on for the co-operative experiments in tree planting, as published in press bulletin No. 22, was in rows six feet apart and four feet apart in the row for irrigated land. This is probably the closest planting that should be recommended and in many cases may be better made 8x4 or 8x5 feet. With these spaces it may be desirable to remove alternate trees in each row after a number of years. To prevent as much as possible the drying effects of sun and wind the plantation should be in as compact form as possible. Thus the area set to trees should not be more than twice as long as wide.

The following table indicates the number of trees per acre when set at the given distance apart, also a suitable length of row for setting a plantation of only six hundred trees.

Spaces	No. of Trees Per Acre	Length of Row	No. of Rows	Width of Plantation
4x6	1850	10 Rods	15	5.5 Rods
4x8	1352	10 Rods	15	7.3 Rods
5x8	1089	12 Rods	15	7.5 Rods
6x12	604	240 Feet	15	11.5 Rods

The following plan which has been successfully followed by Mr. J. C. Cope on the plains in eastern Colorado, will be largely adopted by the station for experimental plantations under similar conditions. The land is ploughed in strips so as to leave dead furrows twelve feet apart with a back furrow, forming a ridge between. The surface of the land is thus caused to slope each way toward the dead furrows in which the trees are set at intervals of six feet apart. These dead furrows are maintained during the first few years of cultivation so that any rainfull, sufficient to cause a surface flow, is directed toward the rows of trees. These depressions also tend to hold the snow in winter which might otherwise blow away.

Heeling In—As soon as the trees are received from the

nursery they should be taken care of without delay. They should be unpacked and either planted out at once or if the land is not ready they should hc heeled in carefully. For this purpose a shady place is preferable if they are to be left for some time. Dig a trench with one sloping side and deep enough so that the roots of the trees will not entirely fill it. The roots of the trees are then placed in the trench while the trunks lie at right angles to it on the sloping surface. Enough moist soil is then thrown on the trees to bury the roots so there will be no danger of drying out, and it is also well to cover the trunks nearly to the tip. The trees should be planted before growth begins.

Fig. 1. The trees as they come from the nursery. a, black locust. b, hardy catalpa.

Flg. 2. The same trees after being properly trimmed.

Fig, 1.

Fig. 2

Trimming—As they come from the nursery the trees will usually need some trimming just before they are set in the ground. All broken roots should be trimmed off and the long sprawling ones shortened somewhat. The tops will also need cutting back to make them correspond to the reduced root system. The accompanying figures will help to explain the extent to which this should be done.

Planting—In establishing a tree plantation or an orchard, careful planting goes a long way toward insuring success. Two persons can generally work to better advantage than one alone,

and if the soil has been well prepared and is moist, the planting of one and two year old seedling trees can be rapidly done. Such trees, which usually run from one to two and one half feet high are to be preferred to larger trees. One person thrusts the blade of a spade to its full depth into the ground and opens the soil by pushing the handle forward. The second person sticks the seedling in behind the spade, which is then withdrawn and the soil is then firmly packed about the tree with the feet. The seedlings should be set a little deeper than when in the nursery to avoid exposure of the roots when the soil settles. For larger trees holes must be dug large and deep enough to accomodate the roots and to leave a slight depression around the tree after the soil is put back. The roots of the trees should be brought in good contact with the soil. If the soil is adobe in character, care should be exercised not to pack it too firmly in filling the holes as it may thus be so hardened as to exclude necessary air and water and greatly retard root growth. It is better in such cases to leave the soil somewhat loose and to settle it after all are planted by a thorough irrigation. If the soil is quite dry at the time of setting, water should be turned into the holes and a layer of dry, loose soil thrown on top after the hole is filled, or if water is available, a thorough irrigation may be given after the trees are set. Great care should at all times be taken to keep the roots of the trees protected from sun and dry air for more than a few minutes at a time. Thus a moist burlap may be wrapped about the roots while the trees are being transported and planted.

Irrigating—Unless the soil is well supplied with moisture at planting time a thorough irrigation should be given after the trees are set to settle the soil and encourage root growth. Further irrigation will depend largely upon the character of the soil, the amount of rainfall and the cultivation given. Water need not be applied oftener than is necessary to keep the soil moderately moist. Trees are usually accustomed to plenty of water during the earlier weeks of the growing season but the supply should be diminished or entirely withheld toward the end of summer to induce early maturing of the wood. Probably little or no irrigation should be given after the first or middle of August in ordinary seasons. Trees sometimes suffer more from drought in winter than summer and where water is available late in the season a final irrigation is desirable after there is no further danger of growth being started.

Cultivation—Cultivation can in a measure supply the lack of irrigation facilities. It is in fact absolutely essential to success on the plains or where the only supply of water is the usual rainfall. Under such conditions surface cultivation not only greatly retards evaporation of moisture from the soil but it tends to allow the rain to penetrate instead of running off. Shallow surface cultivatino therefore should begin as early in spring as the conditions will allow and be continued throughout the growing season at intervals of ten days to two weeks. No crust should be allowed to form but the soil must be stirred after each shower. On irrigated land surface cultivation should follow each application of water as soon as the soil will allow. Cultivation, like irrigation should be discontinued toward the end of the growing season in order to let the new growth mature and thus avoid winter killing.

Press Bulletin No. 26. March, 1906.

The Agricultural Experiment Station

FORT COLLINS, COLORADO.

POTATO PROBLEMS.*

By W. PADDOCK.

A POOR STAND OF POTATOES.—A poor stand of potatoes is usually due to the attacks of plant diseases of various kinds. Two of these minute plants are quite common; one of them causes the seed potato to rot in the ground, and the other attacks the young shoots, often rotting them off before they reach the surface of the ground. In the former instance it will usually be found that the seed potatoes have been injured by improper storage, thus giving certain fungi an opportunity to develop. With the latter instance, a fungus which is associated with heavy, poorly drained soil is responsible. Such soils should commonly be avoided for potato growing. Potato soil contains more or less sand or gravel and is well underdrained.

VINES AND NO TUBERS.—This condition is a common one in many parts of the state, and is largely due to the attacks of a fungus which thrive best in heavy, damp soil. This condition may not appear every year, but usually it will not pay to try to grow potatoes in a soil where this condition is at all noticeable.

POTATO SCAB.—True potato scab is alway caused by the attacks of minute plants, or fungi, and, curiously enough, scab is more common in the best potato soils than it is in localities where the crop is more precarious. Good potato soils, when first brought under cultivation, often give a large per cent. of scabby potatoes

* Because previous Reports on potatoes are out of print, this is prepared to meet inquiries until after the present season.
Nos. 70 and 91, Potato Failures. F. M. Rolf.
No. 92, Large Vines and No Potatoes. W. Paddock.
Press Bulletins Nos. 8 and 12, Potato Failures. W. Paddock.

but after one or more crops of alfalfa have been plowed under, this tendency is partially corrected.

In former publications we have advocated the treating of seed potatoes as a means of preventing potato scab. Some of our experiments with treated seed gave good results, but the majority gave negative results. These experiments extended through four seasons at Fort Collins and at Greeley. Our conclusions are, that in these localities it will not only not pay to treat seed potatoes for scab, but that such treatment may positively be detrimental to the crop. Growers on the Western Slope have reported good results from seed treatment; for this reason formulas are given below.

POTATO BLIGHT.—Potato blight, or the dying of the leaves and vines before the crop is mature, is commonly thought to be entirely due to diseases which attack the top of the potato plant. We have not found it so in Colorado. Spraying experiments with Bordeaux mixture did not materially lessen the blight, and the microscopic plants which cause these leaf diseases are not commonly found associated with this trouble. We concluded, therefore, that the premature dying of the potato vines is usually an evidence that the under ground portion of the plants is diseased. Water applied at the wrong time often so favors the development of this disease that the vines may be seriously damaged in a short time.

INTERNAL BROWN SPOT.—A disease which appears to be identical with what is known as internal brown spot has made its appearance in some portions of the state. This trouble appears to be the result of certain conditions, rather than to the attack of any specific plant disease. All that is known on the subject is summed up in the following paragraph, which was taken from Bulletin No. 87 of the Bureau of Plant Industry, U. S. Department of Agriculture.

> It is considered not to be a parasitic disease, and no remedy is known and no suggestions are made except the doubtful one of avoiding the use of diseased tubers for seed. In England and Scotland several potato specialists of wide experience gave evidence of like purport. The trouble is frequently observed, and is most commonly called "sprain." It is not propagated in seed or soil and is nonparasitic. It is considered to be the direct result of malnutrition associated with unfavorable soil conditions, resulting either from too dry condition or from the lack of potash or lime. It is frequent in light, dry soils during dry seasons, and is never seen on heavy, strong moist soils. The remedy, in the judgment of the specialists cited, lies wholly in attention to cultural conditions and the choice of varieties.

While the conditions described above do not apply to irrigated land, it will no doubt be found that our trouble is due to some condition of soil or culture, or both, which is unfavorable to the proper development of the potato plant.

SEED SELECTION.—Too much emphasis cannot be given to the importance of seed selection. Is should be possible by this means to build up a strain of potatoes which would be adapted to our con-

ditions and which should become better year after year. The following extract is quoted from a former bulletin of this Station:

Another method which gives evidence of considerable practical value is to set aside each year five or ten acres of land for the growing of seed potatoes. The soil of such tract ought to be fertile and free from the various diseases which attack the potato plant. The tubers used in planting the seed tract are carefully selected each year from the seed plot of the previous year. The surplus seed is used for planting the general crop, and in this way a strain of pedigree potatoes is gradually developed.

FORMULÆ FOR TREATING DISEASED SEED POTATOES.

Corrosive sublimate........	1 ounce
Water........................	8 gallons

Dissolve the corrosive sublimate in one gallon of hot water, then dilute with seven gallons of water. Allow the potatoes to soak one and one-half hours. When dry they may be cut and planted, though it has been found to be good practice to treat the potatoes a week or more before planting, since the treatment may retard germination if done just before planting.

Corrosive sublimate is a deadly poison, and it should be used in wooden or earthen vessels, since it corrodes metals.

Formalin....................	8 ounces
Water	15 gallans

Soak the potatoes two hours in this solution, preferably but a short time before planting. This solution is somewhat more expensive than the corrosive sublimate treatment, but it has the advantage of being non-poisonous, and it may be used in any kind of vessel.

Press Bulletin No. 27. July, 1906.

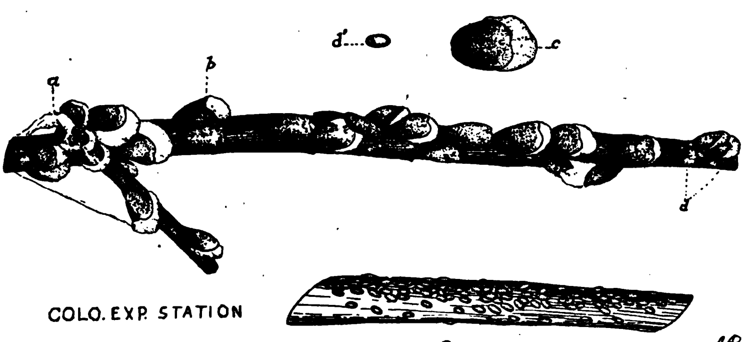
The Agricultural Experiment Station

FORT COLLINS, COLORADO.

THE COTTONY MAPLE SCALE.*

(Pulvinaria innumerabilis)

BY S. ARTHUR JOHNSON.



THE COTTONY MAPLE SCALE: (a) ovisac opened to show eggs; (b) females with cottony mass partly secreted; (c) slightly enlarged female; (d) parasitized winter form; (d') the same slightly enlarged; (e) hibernating winter form. All except c and d' natural size. (Drawn by Miss M. A. Palmer.

The cottony maple scale is a rather common pest on soft maple and some other trees, especially those which are planted in parks and along the streets for shade and ornamental purposes. It belongs to a group of very much specialized insects which have a habit of spending a very large portion of their lives attached to one place on the plant on which they live. During the greater portion of their existence they are covered with a shell of greater or less hardness, which often resembles very closely the surface of the food plant. Owing to these characteristics and the fact that they look so little like insects, they are commonly overlooked by all except those who are making a specialty of studying them. The injury is done while the insect is taking its food. To do this it thrusts hairlike bristles from its mouth into the plant tissues and draws out the sap.

*Based on Bulletin 116 of the regular series.

The cottony maple scale has attracted considerable attention during the past few years on account of its unusual abundance and the injury it has caused in a number of widely separated localities. It is found throughout the middle zone of states in the eastern portion of the country and in many of the far western states. It is a native of this continent and has long been widely distributed. Ordinarily it does little injury because the numbers are too small, being kept in check by its natural enemies. Sometimes these fail for some reason to perform their useful offices and the scale increases in marvelous numbers.

The adult form of the insect is most easily recognized during May and June when it secretes a white cottony mass of wax about the size of a pea from under the scale. These masses appear on the twigs and small limbs. They may range in numbers from a few scattering individuals to where the under sides of the limbs are nearly covered with them. The masses at this time are more commonly found on the lower limbs and most often on the under sides of these. In the center of the fluffy masses the insects lay several hundred tiny oval nearly white eggs and then die. The egg laying continues with different insects from the latter part of May till about the first of July. The eggs hatch in June and July and the tiny young soon find their way to the leaves and begin to feed. Most often they settle on the under sides near the veins, but they are sometimes found on the upper sides and even the young tender shoots. Here they live during the summer without changing their position. It is during this season that the injury is done to the leaves. The old deserted cottony masses still cling to the limbs and are sometimes to be found there for more than a year after they were formed. They, of course, do no injury. In August and September the male scales develop into tiny winged insects, but they soon afterward die.

The females remain on the leaves until October and then migrate back to the twigs and limbs. At this time they are a little over a sixteenth of an inch in length. They fasten themselves for the last time, usually lengthwise the twig, and more often than not on the under side of it. During this fall migration a great many are lost by clinging to the falling leaves and otherwise failing to secure good hibernating places.

Throughout the winter the scales may be found in this position and during this time they take but little if any nourishment.

As soon as the sap begins to flow in the spring they begin to grow. Their color is almost exactly that of the bark and they escape unnoticed. By the latter part of May or early in June they are full grown and measure about three-sixteenths of an inch across. The waxy mass is secreted from the under sides and this gradually raises the insect until it stands at an angle of sixty degrees or more to the twig on which it rests.

As already stated the insect does most injury to soft maple

trees, but it is also sometimes very abundant on black locust and Virginia creeper. Nearly fifty food plants are known, but commonly only the ones mentioned will be so badly infested as to need treatment.

REMEDIES.

The scale is so well protected at most stages of its life that it is very hard to kill without injury to the tree. The best time is during the winter while the trees are in a dormant condition. An insecticide can then be used which is strong enough to kill without injury to the tree. All parts of the tree can be reached, which cannot be done when they are in foliage. The amount of insecticide required is very much less than in summer.

The insecticide most commonly used is kerosene emulsion. This is a mixture of kerosene and water accomplished through the use of soap and made according to the following formula:

Kerosene	2 gal.
Soap	¾ gal.
Water	1 gal.

Dissolve the soap in boiling water and while still boiling remove from the fire and add the kerosene. Then with the force pump, pump the liquid back on itself for five or ten minutes until the mixture assumes a creamy consistency and no free oil rises to the surface when the emulsion is permitted to stand a few minutes. This makes the stock solution. If the oil refuses to emulsify after considerable agitation, the mixture may be put over the fire and warmed somewhat. If this is done, great care must be taken that the oil does not boil over or serious results may follow. If the soap is first dissolved in two gallons of water the resulting mixture will be warmer and more apt to emulsify readily.

Common laundry soap is most readily obtained, but any brand will answer. Whale-oil soap will do equally well. If the water is hard or alkalied it will be necessary to use a larger portion of soap, or to treat the water in a way to soften it. Soft naptha soap is sold by which a good emulsion may be made cold or by only slightly warming the water. It is necessary to use fifty per cent. more of the soap when used in this way. This is a good method where large quantities of the emulsion are to be used and the task of heating the water is a serious problem.

For use on this scale the original stock solution must be diluted until there are four gallons of water to every gallon of kerosene. That is, the original stock solution given above will make ten gallons of emulsion ready to spray on the trees.

The application is made by use of a spray apparatus using a fine misty spray. The nature of the equipment will depend largely on the amount of work to be done. For a few trees a small bucket pump will probably be all that is required. In applying the emulsion, the secret of success is in the thoroughness

of the work. It will be necessary to go over each limb from two sides and beneath, and spray until the emulsion drips. After this the tree should be examined and all the missed spots retouched.

Since the infestion is not always sufficiently severe to require treatment, it will be necessary to make an inspection bef re the task is undertaken. In parks and large grounds it is often wise to select those trees or groups which bear a great many of the insects and permit nature's remedies to take care of the rest.

SUMMER TREATMENT.—Sometimes the pest is so abundant that a summer treatment is desirable. When this is done, the emulsion must be used much weaker than in winter or serious injury will be done to the foliage. The best proportion is probably one gallon of kerosene in fifteen of water. In a very few days after the newly hatched larvae have settled on the leaves they become covered with a scale and are so protected that this strength will not kill them. Since the eggs hatch most abundantly during June and July, it will be necessary to make more than one spraying in order to catch the young while they are susceptible. To do thorough work it will be well to begin about the middle of June and continue the applications at intervals of about two weeks during July.

In cases where the number of trees is small or the insects are on Virginia creeper or grape, they may be treated as soon as the cottony masses show themselves, by trimming out twigs and branches, where such an operation will not mar the beauty of the plant, and thoroughly soaking the remaining masses with kerosene emulsion which is one-fourth kerosene. This emulsion may be applied with a brush or sponge and must, of course, be kept from the foliage, which it will destroy.

A fuller but more technical account is given in bulletin 116 of the regular series.

Press Bulletin No. 28. November 1906

The Agricultural Experiment Station

FORT COLLINS, COLORADO

A NEW ALFALFA DISEASE.

By W. PADDOCK.

Up to the present time the alfalfa plant in Colorado has been practically free from diseases. It is true that leaf-spot is always present and in damp situations a mildew often makes its appearance The former disease causes a considerable amount of damage in the aggregate but after all its presence is not usually considered. But recently a bacterial blight has appeared and in some localities it has been quite destructive. The purpose of this bulletin is to call attention to this newer disease and through this means get in touch with infected localities.

Complaints have come to the Experiment Station from one locality for the past three seasons of the dying out of alfalfa plants in the spring. The growers could scarcely believe that the trouble was due to winter injury since it had not occurred before under similar conditions, and since dead plants were found alike on high and on low land, and on wet and on dry situations. The presence of numbers of small maggots in the decaying crowns was the most popular theory advanced to account for the dead plants. On visiting the fields early in the spring it was evident that winter injury could not have caused the damage and that the maggots were only present because of the decay and not as a cause of it.

In June of the present year, we had the first opportunity of inspecting the fields during the growing season. The cause of the injury was now apparent as the numerous blackened stems from which a thick juice was oozing plainly indicated a bacterial blight, and subsequent examination has shown this to be the probable cause of the trouble.

The first evidence of disease to be noticed by the casual observer is a short, weak and light colored growth of the first crop, and the stems, even over a large field, may not average over a foot in height

at the time the first cutting is usually made. A close examination shows that a majority of these stems are discolored, in fact nearly black, for a portion of their length, and drops of dried juice will be found on many of them. Such stems are also very brittle, and easily broken. The disease apparently does not kill many plants the first year, but in time so many of the plants die that the fields are useless.

The disease evidently runs its course for the season with the first crop and those plants which have sufficient vigor make satisfactory growth for the second and third cuttings and little or no trace of blight is seen during the remainder of the season. But the following spring a renewal of the outbreak may be expected.

The plants begin to die after the blight has been abundant for more than one season as the decay appears in the crowns of the plants and may involve the tap root. The crown buds are thus destroyed or the nutrition may be so interfered with that the plants die.

Almost nothing is known of this blight as yet, consequently remedial measures cannot be discussed except that it seems to be advantageous to cut the first crop early and to delay the date of the first irrigation until after this time if possible.

The horticultural section of the experiment station solicits correspondence with any one who has reason to believe that this disease is present in his fields. Means have been devised for combatting most plant diseases and we believe that this one will be no exception. However, it is important that its nature be understood at the earliest possible moment and one of the important means to this end is through the experience of growers. It is for this reason that we invite co-operation.

Twenty-Eighth Annual Report

OF THE

State Board of Agriculture

AND THE

State Agricultural College

INCLUDING THE

NINETEENTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

FORT COLLINS, COLORADO

1906

DENVER, COLORADO
THE SMITH-BROOKS PRINTING CO., STATE PRINTERS
1907

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LETTER OF TRANSMITTAL.

To His Excellency,
THE GOVERNOR:

Sir—Herewith I transmit my annual report as Secretary of the State Board of Agriculture. It is respectfully commended to your attention and to the thoughtful consideration of the General Assembly.

A. M. HAWLEY,
Secretary of the State Board of Agriculture.

The State Agricultural College,
Fort Collins, Colorado, November 30, 1906.

SECRETARY'S REPORT.

REPORT OF THE RECEIPTS AND DISBURSEMENTS OF THE COLLEGE FUNDS FROM DECEMBER 1, 1905, TO NOVEMBER 30, 1906, INCLUSIVE.

RECEIPTS.

Tax Fund.		
Balance, December 1, 1905	$ 3,961.55	
Receipts	69,755.00	
		$ 73,716.55
Land Income Fund.		
Balance, December 1, 1905	$ 1,357.22	
Receipts	18,354.31	
		19,711.53
Annie Jones Library Fund.		
Balance, December 1, 1905		1,175.31
Special Fund.		
Balance, December 1, 1905	$ 1,432.61	
Receipts	12,590.03	
		14,022.64
Appropriation Agricultural Instruction Fund.		
Balance, December 1, 1905		3,986.77
Appropriation Farmers' Institute Fund.		
Balance, December 1, 1905		7,102.66
United States Mechanic Arts (Morrill) Fund.		
Balance, December 1, 1905	$ 8,416.79	
Receipts	25,000.00	
		$33,416.79
		$153,132.25

DISBURSEMENTS.

Agricultural Department—		
Agronomy Division	$ 780.72	
Animal Husbandry Division	5,414.25	
Farm Division	5,842.15	
Farm Mechanics Division	236.58	
General Agricultural Division	4,732.20	
Farmers' Institute Division	5,003.19	
		$22,009.09
Advertising		2,039.28
Bulletins and Reports		1,114.30
Association A. A. C. and Experiment Stations		15.00
Chemical Department		759.75
Commercial Department		16.65

DISBURSEMENTS—Continued.

Constitutional History and Irrigation Law Department	53.85	
Current Expense	804.10	
Civil and Irrigation Engineering Department	2,019.17	
Domestic Science Department	551.06	
Rhetoric and Composition Department	9.15	
Electrical Supplies	162.90	
Freight and Express	1,557.01	
Fuel and Lights	4,785.86	
Firemen and Janitors	3,282.26	
General Repairs	2,043.04	
Girls' Dormitory	785.41	
Horticultural Department	3,465.00	
History and Literature	27.50	
Insurance	993.75	
Library	2,695.19	
Mechanical Department	2,368.39	
Mathematical Department	8.60	
Military Department	74.22	
Music Department	118.84	
Modern Languages Department	13.45	
President's Office	1,442.67	
Physical Training Department	17.30	
Permanent Improvements	14,060.31	
Salary	61,807.02	
Secretary's Office	985.82	
State Board of Agriculture	1,291.40	
Student Labor	3,655.80	
Text-Book Department	3,305.01	
Veterinary Science Department	352.30	
Zoology and Entomology Department	222.66	
Transfers to other funds	3,790.28	
		$142,703.39
Tax fund.		
Overdraft, November 30, 1906	$ 1,994.55	
Land Income Fund.		
Balance, November 30, 1906	$ 358.05	
Special Fund.		
Balance, November 30, 1906	3,210.80	
United States Mechanic Arts (Morrill) Fund.		
Balance, November 30, 1906	8,854.56	
		$10,428.86
		$153,132,25

REPORT OF RECEIPTS AND DISBURSEMENTS OF FUNDS PAID INTO THE SECRETARY'S OFFICE IN CONNECTION WITH SPECIAL FUND.

RECEIPTS.

Domestic Science Department		$ 10.25	
Mechanical Department		36.33	
Chemical Department		57.50	
Freight, etc., Refunded		195.60	
Text-Book Department		2,884.00	
Entrance Fee		380.00	
Library		66.95	
Music Fee		207.75	
Horticultural Department		11.25	
Girls' Dormitory		345.61	
Registration Fee		36.00	
Physics Department		9.85	
Civil and Irrigation Engineering Department		270.00	
Appropriation		3,328.41	
Agricultural Department—			
General Agricultural Division	$ 725.06		
Agronomy Division	28.57		
Animal Husbandry Division	4,805.64		
Farm Division	32.40		
		$5,591.77	
			$13,431.27

DISBURSEMENTS.

Remitted to the State Treasurer for credit of Special Fund as per receipts on file	$13,431.27

REPORT OF THE RECEIPTS AND DISBURSEMENTS OF THE EXPERIMENT STATION FUNDS FROM DECEMBER 1. 1905, TO NOVEMBER 30, 1906, INCLUSIVE.

RECEIPTS

Hatch Fund.		
Balance, December 1, 1905	$ 1,554.40	
Receipts	15,000.00	
		$16,554.40
Adams Fund.		
Receipts		$ 6,750.00
Special Fund.		
Balance, December 1, 1905	$ 686.05	
Receipts	5,756.23	
		$ 6,442.28
Appropriation Animal Industry Fund. Balance, December 1, 1905		$ 9,360.76
Appropriation Plant Industry Fund. Balance, December 1, 1905		$ 2,058.29
Appropriation Root Crops Fund. Balance, December 1, 1905		$ 1,000.00
		$42,165.73

DISBURSEMENTS

Agricultural Section	$ 56.27	
Arkansas Valley Sub-station	54.12	
Animal Investigation Section	2,024.11	
Agronomy Section	2,483.55	
Bulletins and Reports	5,457.19	
Buildings	5,236.68	
Chemical Section	1,345.47	
Director and General	1,716.58	
Entomological Section	1,053.05	
Horticultural Section	1,570.48	
Insurance	33.00	
Library	1,912.63	
Meteorological and Irrigation Section	2,347.39	
Salary	11,136.07	
Veterinary Section	951.83	
Western Slope Fruit Investigation	2,428.11	
Transfer to other funds	1,124.57	
		$40,931.10
Hatch Fund.		
Overdraft, November 30, 1906	$ 286.47	
Adams Fund.		
Balance, November 30, 1906	455.26	
Special Fund.		
Balance, November 30, 1906	1,065.84	
Balance, with Treasurer, November 30, 1906		$ 1,234.63
		$42,165.73

REPORT OF THE RECEIPTS AND DISBURSEMENTS OF FUNDS PAID INTO THE OFFICE OF THE SECRETARY IN CONNECTION WITH THE EXPERIMENT STATION SPECIAL FUND.

RECEIPTS

1905-1906.

Horticultural Section	$ 10.74	
San Luis Valley Sub-station	280.09	
Director and General	599.19	
Arkansas Valley Field Agent	8.00	
Agronomy Section	265.34	
Western Slope Fruit Investigation	1,424.87	
		$ 2,588.23

DISBURSEMENTS

Remitted to Station Treasurer for credit of Special Fund as per receipts on file	$ 2,588.23

SUMMARY

NAMES OF FUNDS	1905 Balances	Receipts	Disbursements	1906 Balances
College				
Tax Fund	$ 3,961.55	$ 69,755.00	$ 75,711.10	*$ 1,994.55
Land Income Fund	1,357.22	18,354.31	19,353.48	358.05
Library	1,175.31	....	1,175.31	....
Special	1,432.61	12,590.03	10,811.84	3,210.80
Mechanic Arts (Morrill) Fund	8,416.79	25,000.00	24,562.23	8,854.56
Appropriation				
Agricultural Instruction Fund	3,986.77	....	3,986.77	....
Farmers' Institute Fund	7,102.66	....	7,102.66	....
Animal Industry Fund	9,360.76	....	9,360.76	....
Plant Industry Fund	2,058.29	....	2,058.29	....
Root Crops Fund	1,000.00	....	1,000.00	....
Experiment Station				
Hatch Fund	1,554.40	15,000.00	16,840.87	*286.47
Adams Fund	....	6,750.00	6,294.74	455.26
Special Fund	686.05	5,756.23	5,376.44	1,065.84
	$42,092.41	$153,205.57	$183,634.49	$13,944.51
				2,281.02
				$11,663.49

*Overdraft.

REPORT OF THE PRESIDENT.

The State Board of Agriculture:

Gentlemen—I submit the following as the Twenty-seventh Annual Report to The State Board of Agriculture. It is accompanied by reports from the heads of the various departments, for which I ask the most careful hearing.

The year has been one of remarkable vigor in the prosecution of the work of the Institution, both in the school and throughout the State. The College and Experiment Station, realizing their obligation to the active farmers of the State, many of whom have recently come to Colorado, have done as much extension work as time and means would permit. Farmers' institutes have been held in many parts of the State. Important bulletins have been printed and widely circulated. Two horticultural experts have been established on the Western Slope in connection with the fruit growers of Mesa county. Much good has issued from this; chiefly, the organization of the fruit growers of the Western Slope, for the protection of their industry and for giving assistance to the College. Many valuable experiments are in action, and orchardists are patiently awaiting final results. I recommend that in the appropriation bill you ask for $20,000 for Horticultural experiment work throughout the State.

The College experts have visited every portion of the State where perplexing difficulties have arisen and have given much valuable aid. The Farmers' Course is in session at the present time with an enrollment of seventy-five. A short course in forestry will be held here February 18th as ordered by this Board. A school in horticulture for the Western Slope will be held in Delta, beginning January 14th and lasting one week, which gives promise of being the most successful effort the College has recently attempted . A remarkably fine exhibit from the College and Experiment Station was made this year at the State fair and several of the smaller fairs. The cost was considerable, but I am sure it was a paying investment. It will be much less expense hereafter.

Correspondence with practical farmers has greatly increased, and much practical work is being carried on, as the accompanying reports will show. I am sure the Board realizes the importance of this extension work. It carries the College directly to the farmers, who need its help. It makes them positive and lasting friends, and makes it far easier to reach the farmers' children and interest them in the work of the College. Like all honorable effort to do one's duty, it brings its own rewards. I think the State wil gladly grant the Institution at least $8,000 a year for the further prosecution of this extension work.

The work of the school has grown more stable and logical. The Board is a unit in its determination to give to the four great departments, i. e., Agriculture, Civil and Mechanical Engineering and Domestic Science, equable support. Upon these four corner stones we are rearing a substantial structure.

A few changes in the teaching force have been made. Those who have recently come to us are strong men and are giving marked satisfaction. Any school might be proud to have its entire faculty composed of such men as Bainer, Coen, Cottrell, Gay and Paull. They have been selected with great care and are more than fulfilling our expectations. I question if a stronger Faculty may be found in any Agricultural College in America than the one this Board has the honor to direct.

As the Board is well aware, the work of this Institution for some years past has been fundamental. We have strengthened the courses of study by striking off the first preparatory year, by adding a year at the top of each course, and by such other changes in the remainder of the curriculum as will best make excellent working experts and good citizens. We have been searching, in fact, for the best possible Agricultural College Curriculum, keeping always in mind the needs of our own State. The Land Grant Colleges have been compelled to slowly find their destiny in the educational world. We think the problem has at last been solved. Their function is three-fold: experimentation, instruction and dissemination. These are met by the Experiment Station, the College, and the institute or extension workers. More and more the members of each of these three groups must work each within his own group. To be sure the ideal condition is that the experimenter shall teach enough and mix enough with the active farmers to keep him fresh and give proper direction to his experiments.

In spite of the lopping-off process, by which four courses have been eliminated from the Institution, we have held our own in enrollment, with a decided gain this present year.

The short course scheme, for which we all have worked so long, has come to stay. Nearly one hundred young men and women are with us at the present time for the three months' work. Some twenty who were here last winter have returned for more advanced work. Others returned last fall for the long courses. These short course students are bright, hard-working and appreciative. I trust their number will increase so rapidly that by another year we may find it advisable to abandon the First Sub-Freshman year of our present system. Then our student body will have a higher age average, come better prepared, having finished the tenth grade elsewhere, and the school will be able to assume more college-like methods. Every alumnus with whom I have talked supports this proposition.

By reason of our constant growth, our fixed charges have become so great that new buildings, or the enlargement of the

present buildings, have been out of the question. Until more room is provided we should not hope for a great increase in enrollment, for it will be impossible to provide comfortable accommodations. With the addition of one hundred short course students now here we are uncomfortably crowded. Many departments are severely handicapped for lack of space. It is clear, therefore, that large appropriations must be asked of the Sixteenth General Assembly if we are to do more than retain our present development. I advise the calling together of those in charge of the departments of Agriculture, Civil Engineering and Domestic Science, at once, for a conference on new buildings. An Agricultural Hall, a Civil Engineering Building and a combined Domestic Science and Girls' Dormitory building must be had within the next two years by some process. It is probable that if two of these could be secured by special appropriations the third may be provided for by private generosity; but procured they must be. The time is favorable, the need is imperative, and the wisdom of the Board must do the rest.

As already stated, further appropriations are needed for extension and experimental work. These requirements will be presented to you in accompanying reports.

I should now like to ask you to consider some important legislation. The State Forestry Association has issued a Memorial to the State in general, and the coming Assembly in particular, in which they ask for the establishment of a Chair of Forestry in this Institution, with sufficient appropriation from the State for its support. This means, if it is to succeed, that the Board must give the measure its heartiest support. We should give the matter a definite expression at this time. No State in the Union is making or will make such demands for instruction in the growth and preservation of forests. Irrigation being the basis of our agriculture, it might almost be said that the mountain forests are the basis of irrigation. If a Chair of Forestry is to receive state or government aid in Colorado, it must be patent to everyone that it should have connection with a State Institution. The State Agricultural College already has much of the equipment needed, a number of the present members of its Faculty have been giving elementary instruction leading to more advanced work. The establishment of such a Chair in this Institution would at once claim the confidence of the entire State.

Professor Gillette has proposed a bill which makes the Entomologist of the College the State Horticultural Inspector, with a company of deputies. The former is to be paid by the State, the latter by the counties wherein the work is done. Owing to the fact that Colorado is fast becoming the first fruit State in America, and that already great injury has been done the industry by reason of ignorance and negligence, such legislation as is here indicated is greatly needed. The leading fruit men of the

State will give it their unqualified support. I recommend that the measure have the full endorsement of this Board.

I desire to know if it be your wisdom that the time is opportune for the introduction of a bill requiring the teaching of elementary agriculture in the rural schools of the State after, say, July 1, 1908. The State Normal School avows itself as willing to co-operate with us both in respect to the bill and in giving at the State Normal a course which shall prepare teachers in this branch by the time the law becomes operative. There are many reasons for enacting such a law. There are a few in opposition; mainly, however, as to the timeliness of such a measure in Colorado.

In all probability a measure will be introduced before the coming Assembly, asking for an appropriation for experimental work in dry farming on the plains. The Department of Agriculture, at Washington, stands ready to grant a sum equal to that which shall be appropriated by the Legislature for dry farming experimentation, provided the work is carried on by this Institution in conjunction with the United States Government. It will be necessary for the Board either to prepare the bill, or look after its interests if the bill is proposed by others.

Some general legislation must be had by which the State revenue shall be increased. This must be done either by amendment to the Constitution, adding one or more mills to the four mills state tax, as at present, or by a legislative enactment to the present revenue law and the present methods of assessment. A conference of all institutions is to be held at an early date to seek relief in this direction. Representation in this conference must be provided for at this meeting of the Board. It is of supreme importance. The State is now possessed of sufficient wealth adequately to care for all of its institutions. The reason for the present lack of funds lies either in the method of assessment or in the fact that the State has not provided itself with a sufficient mill rate.

Another member of the Board will report later relative to a proposed bill concerning the relationship of this Institution to the State Land Board and the college lands now under its control.

This, I believe, covers the legislative question, apart from appropriations. And these can only be determined upon by you after consultation with the Departments of Agriculture, Domestic Science and Civil Engineering.

I wish to recommend that your permission be granted the Committee on Faculty and Courses of Study to prepare for the next annual catalogue a new course of study for women.

I feel that a more general course, in addition to the present Domestic Science Course, will attract many more women students than we seem to be able to reach at the present time. Domestic Science should by all means hold a dominant place in the new course, if one is to be formulated.

I desire also to recommend that so far as possible a special crew be provided for institute work, if sufficient appropriations are made by the coming Legislature, in order that the members of the Faculty may not be overtaxed in time or energy, as at present, often to the injury of their regular class-room work in the College.

I desire also to recommend that at the earliest possible moment buildings and money will permit the course in Veterinary Science be restored. The recent meat inspection bill passed by Congress has greatly increased the demand for competent veterinarians, who shall instruct stockmen in a proper care of animals and in the prevention of diseases.

There are some other minor recommendations which I shall submit later, since they are merely formal and do not require Special Committee action.

Respectfully,

B. O. AYLESWORTH,

President.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF AGRICULTURE.

To the Honorable State Board of Agriculture:

Gentlemen—I have the honor to present herewith my third annual report covering the work of the Agricultural Department of the College and Experiment Station during the past year.

Several changes have been made in the staff of this Department during the year. Prof. J. A. McLean, who occupied the Chair of Animal Husbandry, resigned in June to accept a more lucrative position in the Iowa Agricultural College. Prof. H. M. Cottrell, formerly professor of agriculture in Kansas, was secured to fill this position.

Pursuant to instructions received at a former meeting of the Board, a Committee composed of the President of the College and the writer, secured Prof. H. M. Bainer, Professor of Farm Mechanics in the Iowa Agricultural College, to take the Chair recently established in Farm Mechanics in this Institution. Professor Bainer came to us the first of July this year and has already accomplished a great deal in the way of organizing this Department. He has added a vast amount of farm machinery to our already very good collection, and his work with students in operating this machinery and in carrying on some investigations with motive power has been very successful.

The appropriation made by the last Legislature for the carrying on of experimental work in the Divisions of Agronomy and Animal Husbandry has aided us greatly in carrying the research work done in this Department along these lines.

Since the last annual meeting, the new experiment horse barn, with a large number of corrals and paddocks, has been completed and is now occupied by the horses and colts in the co-operative horse breeding experiment.

The steer feeding and the hog feeding experiments proposed in my last annual report have been undertaken and are well under way, giving promise of some results that will be of great value to the live stock interests of this state.

Through the kindness of Mr. F. J. Hagenbarth, ex-President of the National Live Stock Association, we have been provided with a carload of choice lambs for the carrying on of feeding experiments the present winter. The lambs are now on feed at the College barns and an experiment has been outlined in which we will test the comparative value of finely cut or ground alfalfa meal with alfalfa hay as a feed ration for fattening lambs.

The work in hog feeding as outlined is very elaborate, and is, in brief, to make a study of the grains and other feeds that are available for hog feeding purposes in this state in an effort to determine their comparative feeding value for the production of high class meats, more particularly the production of choice bacon. I believe that Colorado possesses greater possibilities along this line than are to be found in any other state in the Union, and I feel that it is the duty of the College and Experiment Station to point the way in this field of endeavor to the farmers and stock men of the State. From information received from one of the large packers in Denver it is apparent that over $4,000,000 worth of hogs and pork products are annually shipped into this state to supply the market here. If, by carrying on some investigations that will give some definite information on this subject, we will be able to direct the farmers and stock men along the channels of pork production it will be the means of greatly increasing this industry, which is now a comparatively neglected one.

A very complete hog feeding yards and stables have been constructed and are now ready for occupancy. These pens and yards have been divided into ten equal parts and will accommodate 100 head of hogs. With these yards the station is fairly well equipped for investigation work on a small scale.

The proposed lines of investigation in hog raising is submitted by Professor Cottrell in his report, a copy of which is herewith presented, which will give a definite idea of the work that we hope to accomplish in the near future if funds can be appropriated for the carrying on of this work.

The horse breeding experiment is going forward in splendid form. We have, as a result of the year's work, fourteen very promising colts from the eighteen mares bred. Recently the Department of Agriculture has increased the stud of breeding mares by two very good individuals from Kentucky. The five yearling colts are doing well and we hope will develop into something that will bring some revenue for the future conducting of this experiment.

LIVE STOCK.

The stock on the farm has increased in numbers and in quality during the past year, with no great expenditure of funds. The inventory shows that we have on the farm at present fourteen head of Shorthorn cattle, valued at $2,105; five head of Hereford cattle, valued at $625; seven head of Holsteins, valued at $875; seven head of Ayrshire cattle, valued at $650; two Red Polled animals, valued at $250; ten Aberdeen Angus cattle, valued at $1,360; one Highland cow, valued at $60; five steers and two spayed heifers, valued at $560. The total value of cattle owned by the College is $6,485.

In sheep we have seven head of Oxfords, valued at $200; nine head of Southdowns, valued at $160; of Rambouillet, four head, valued at $75, and thirteen head of Shropshires, valued at $360, making a total of $795 worth of sheep owned by the College.

In the hog department, we have thirty-three head of Poland Chinas, valued at $592; nine head of Berkshires, valued at $475; nineteen head of Tamworths, valued at $565, and one Yorkshire sow, making the total valuation of our swine amount to $1,709.

In the horse department in the past year we have added two of the finest Percheron mares in America. This purchase has been made possible largely through the liberality of one of the largest importing firms in America. One of these mares produced a very fine colt this summer, and is, I believe, again in foal. We also have added a pair of work horses, giving us a total of twelve head of horses. These horses are valued at $3,515, making the total valuation of live stock owned by the College, at a very conservative estimate, amount to $13,141.

Owing to the increase in number of our live stock made necessary by the horse-breeding experiment and the steer-feeding experiment the additional pasture of 560 acres purchased early in the spring enabled us to have good pasture all summer for our stock and to have them in good condition for the coming winter. With the inevitable increase in breeds that we must maintain to successfully carry out our plans, I would respectfully recommend that an additional tract of land consisting of another 240 acres lying immediately north of the tract purchased from Benny Harris, that is now for sale, should be secured without delay. The 560 acres purchased during the past summer has not an adequate water supply. The half section mentioned as lying north of it contains a large lake which would give an abundant supply of good water for our stock at all times without any added expense. As this land is constantly increasing in value it would seem to be the part of wisdom to secure it without delay. The land purchased in the spring has been fenced on three sides with good woven wire fencing. It still requires some additional fencing to make it safe.

The addition of the Experiment Farm that we have had possession of for the first time this year has made possible a line of work in grain, grass and root investigation under the direct charge of Professor Olin and his assistant, Mr. Knorr, that is bound to be of the greatest value to the agricultural interests of this State. The research work along the lines of increasing the disease resistant powers of plants is in itself promising great returns for the money expended. In addition to the alfalfa work started, a study has been made of the most important varieties of oats, samples of which have been secured from all over the United States and from the countries of the Old World as well. Some of these varieties have proven exceedingly prom-

ising, one of them yielding at the rate of 127 bushels per acre of clean oats. There was also grown in the experimental plots the common varieties of barley and the common varieties of wheat, including those of strong drouth resistant powers which were grown without irrigation. The research work started this year in a study of sugar beets, looking toward the increase of the sugar content and the production of Colorado grown seed is very promising of the results desired.

The work in variety tests on the Experiment farm has been the most expensive ever conducted at the College, the following being the complete record:

Varieties of oats, 28, two increase plots; varieties of wheat, 23, two increase plots; 17 varieties of barley, three of corn, 24 of sugar beets, a like number being for cultural experiments, nine of rutabagas, five of mangels, six of carrots, nine of peas, and some 20 plots of miscellaneous plants.

Already the land available for experiment work is crowded with variety test investigations. We must soon make some arrangements for additional land where the most promising of these varieties can be tested in the field on a larger scale, and when they have proven their superiority over varieties in common use among the farmers, we can produce them in sufficient quantities for distribution throughout the State. I sincerely trust that the option on 80 acres of land lying immediately south of the Experiment Farm, and known as the Mrs. Taylor place, may be secured this winter, that this very important work may be carried on. I would respectfully urge upon the Board the necessity of having the importance of this matter presented to the Legislature at its coming session with a sufficient appropriation for securing this land.

The cooperative work undertaken with various farmers throughout the state has been productive of valuable results. This has been treated of very fully by Professor Olin in his report, which has been submitted to the Director of the Experiment Station. I trust that this line of work may be carried on in the future and extended in its scope, as its results are of great value to the farming interests of our State.

The Farm Mechanics Division of the Agricultural Department presents some of the most important problems for solution, and I would urgently request that this Division be made a section of the Experiment Station at once. A vast amount of research work is already crowding us in this direction. With the great progress that has been made in motor engines and the demands for them at the present in farm operations makes the duty almost imperative. If the farmers of the State of Colorado are to continue to lead along agricultural lines, they must do so through the medium of improved machinery, and it is the duty of the College and Experiment Station to fully investigate the farm machinery offered on our markets, that we may recommend the kind most likely to be of benefit to our farmers.

Another very important phase of the Farm Mechanics work just now pressing in Colorado and one which has attracted a great deal of attention on the part of our business men, is that of road building. This properly belongs to the Farm Mechanics Division of our College, and I hope that it can be made a strong feature of the work offered to students. I do not believe there is anything at the present time that we could do that would tend to popularize our Institution more quickly than such a course in road building as we could put in.

The Farmers' Institute Division of the Agricultural Department of the College has met with a very gratifying success. This work has been fully reported upon by the Superintendent of Institutes, a copy of which is presented herewith.

The College farm proper was never in as good condition as it is at the present time. The fences have been improved and extended and the ditching and drainage contemplated has been partially completed. There is still much to do in the way of leveling various sections of the farm that will render it much more valuable, for it can then be successfully irrigated. If this could be done it would enable us to supply a larger portion of the feed required for the live stock as this Division grows. More fences and corrals will be required the coming year and we will also require more equipment in the way of horses to enable us to properly care for the land that we have and for that which we hope to acquire. I trust that these may be forthcoming when the time arrives.

INSTRUCTION.

It is very gratifying to report that never before in the history of the College has so much interest been shown by the students in the Agricultural Department. We have registered this year in the various classes of the Agricultural Department of the College 110 students, not including those who will attend the two short courses that are now being offered.

Owing to the additions to our teaching force, the work of instruction is now on a broader scope and substantial gains have been made in attendance. Sixty students of the first and second Sub Freshman years who have signified their intention of taking the Agricultural Course have been organized into a special class and are being given some instruction in live stock work. This is supplying in part a long felt demand on the part of these students for some practical work in the lower classes of our College, and I am sure it will be of great influence in encouraging them to continue in their College work.

With our present equipment of buildings, we will be able to work along for a time without additional class rooms by using the offices of the various instructors as class rooms for some of the more advanced students where the classes are small. If the attendance increases very much, as it has every prospect of doing,

there will be a serious demand for increased class room accommodations in the very near future.

A number of our best students desire to continue their work here after graduation, particularly with their study of live stock, and as they can aid us materially in the investigation work we have under way, I trust that you may see fit to provide from time to time a sufficient number of scholarships to enable these young men to carry their work to completion and to enable us to have the benefit of their services.

NEEDS OF THE DEPARTMENT.

As before stated, we should have additional land for the successful carrying out of our College and Experiment Station work. The one-half section of pasture land we should secure will not cost above $12 per acre, or $4,000. The 80 acres adjoining the Experiment Farm will cost $250 per acre, or $20,000 in all. This additional land would give us sufficient area to carry forward our work in both Agronomy and Animal Husbandry Sections for many years to come. Since options have been obtained on this land it would seem almost imperative that a special effort be made to secure it at this time.

We are greatly in need of a suitable building for storing experimental grains. The upper floor of the Farm Mechanics building makes a very satisfactory laboratory for carrying on seed selection work and in storing the smaller samples for seeding the experimental plots which were started this last year, but it will be necessary to take care of the seed resulting from these experiments if any lasting good is to be derived from what we have already done. A suitable building could be erected for about $3,000. This would give us facilities for putting in apparatus to test the milling properties of the various wheats that are being experimented with. The wheat farmers of this state have suffered a great loss through a combination on the part of the millers of the state the past season to keep down the price of durum wheat, claiming that it made inferior flour. It seems very important that milling tests of this and other wheats should be carried on and this could be done in a suitable grain room, reliably and very cheaply on a small scale, as it is now being done in Minnesota, Utah and Washington Experiment Stations. It is desirable to test all wheats grown and developed here for their milling qualities and we should be able to do this in our own laboratory.

Owing to the large amount of machinery that has been secured at no cost to the College other than the payment of freight, it is necessary for us to make some further provision for the housing of this machinery. We have had donated to this Institution $12,500 worth of machinery and if the manufacturers are showing sufficient interest to let us have the use of their machines for demonstrations and tests it is certainly up to us to see that it is

properly taken care of. Such a building as we have had in mind could be constructed for not to exceed $2,500, and this would enable us to remove the machinery now stored in the class room recently built for demonstrating the working of Farm machinery, for the use of students, in the regular as well as the short courses.

In our experimental work with live stock the appropriation received from the last Legislature should be duplicated and an additional amount secured if possible. The stock men of the state are evincing a great deal of interest and are supporting us in every way. I believe the time is opportune to ask for liberal appriations for every division of our work. We have been receiving annually, for the past two years, $5,000 from the special appropriation, and we should have the same amount for the next two years for live stock experiments.

In the Agronomy Department, we have been getting from the State appropriation annually, for the past two years, $2,500, and this should be doubled, that the work may be taken care of as it should be, that we will not be subjected to criticism for neglecting to care for our experiment work through lack of funds. This amount would be sufficient to carry on the work in the improvement of alfalfa and other forage plants, as well as the root crops and the cereals that we have already under way.

In the Farm Mechanics Section, the sum of $1,500 in addition to the amount required for store room will enable us to carry forward this new branch of our work in a very satisfactory manner.

For Farmers' Institutes we have been receiving $4,000 annually for the past two years, and to make the work more effective an additional $1,000 should be asked for, making $5,000 available annually for this work. This will enable us to issue a hand book prepared by our institute lecturers in the form of an annual report to be distributed among the farmers of the State.

There has been an urgent demand from all parts of the State that a Poultry Department be established at this College. This, it seems, is a very important division of College and Experiment Station work and should receive some attention from us, and I believe there is an excellent opportunity to secure, from the Legislature funds to establish such a department. The expense would not be great and the returns from it when once well established should be greater than the expense in maintaining it. I think we could put in a respectable plant and maintain it for the next two years for not to exceed $4,000. This would enable us to erect suitable buildings, to equip the course and to employ a man to take charge of the work, which will be a necessary expense.

The total amount required by the Agricultural Department for the next biennial period, including purchase of land, erection of buildings, purchase of equipment, Farmers' Institute work, and the carrying on of proposed investigations in the Agronomy, Animal Husbandry, Farm Mechanics and Poultry Divisions, is in

round numbers $62,000, of which $24,000 is for the purchase of land, $5,500 for the erection of much needed buildings, $4,000 for Poultry Department, $10,000 for Farmers' Institute work, $10,000 for Animal Husbandry work, including the horse breeding experiment, $6,000 for Agronomy and $3,000 for Farm Mechanics, including road building. Our experience has taught us that we can not depend upon any great amount from the Hatch and Adams funds except in the matter of salaries without encroaching on other lines of investigations equally as important, else this amount asked for might be reduced appreciably in the Agronomy and Animal Husbandry Divisions.

In conclusion, I take this opportunity to express my deep appreciation of the courtesy and kindness of the Board during the past year in granting me a four months' leave of absence in order that I might be enabled to study the practices of the leading stock breeders of Europe. I wish also to express my appreciation of the liberality of the Board in providing ways and means for the carrying on of the most important demands of work in the Agricultural Department.

Respectfully submitted,

W. L. CARLYLE,

Dean of Agriculture.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE AGRONOMY DIVISION OF THE AGRICULTURAL DEPARTMENT.

Prof. W. L. Carlyle, Dean of Agriculture, Colorado Agricultural College.

Dear Sir—I take pleasure in giving you a detailed report of the work of my Department from December 1, 1905, to December 1, 1906.

1. *Class Work.* This past year I have had classes in Agron omy work, as follows:

Winter term, 1905-6, a class of twenty-five in Farm Mechanics; the work of this class consisted of class lectures once a week and shop work in iron and steel ten hours per week. The State Poultry Association offered prizes for the boys of the Farm Mechanics class who presented the best and most practical Colony Poultry House. Albert Cross, L. C. Aicher and R. C. Littler went to the State Association held in Denver in January with models of poultry houses which they had made in the shop. The boys explained the plan of their houses to the hundreds of visitors who inspected them, and one dealer in fancy poultry has adopted Mr. Littler's design for his colony houses. This work attracted favorable attention, and the State Poultry Association stands ready to assist us in a substantial manner in making this work interesting and of practical value to the boys. Prizes were awarded on the models shown: Littler, first; Aicher, second; Cross, third. I have recommended to Prof. Bainer (who now has this work) that it be broadened and emphasized, and that the Poultry Association be invited to give liberal prizes each year for models of colony houses from original designs; that other prizes for practical models, useful on the farm, be secured from interested individuals or associations. The shop work in iron and steel consisted of fourteen practical exercises in forging. Mr. William Elzinga, Instructor in Moulding, Forging and Foundry Work in the Mechanical Department, was the instructor in the shop work, and while he had very large classes in the Mechanical Course, by some changes he found room and time for the Farm Mechanics shop work and reported a deep interest in this work on the part of the boys. As soon as we can, we should have shop arrangements especially adapted for Farm Mechanics instruction, so we will not need to so seriously inconvenience the work and workers in the regular Mechanical Engineering shop work.

This term I also had the Junior students in the Agricultural Course in Study of Soils three times a week. While there had been no arrangements for definite laboratory periods in the

catalogue for this work, the class found time to take laboratory work. Mr. Knorr directed the laboratory work in Soils. We had practically no apparatus for this work, no place to store said apparatus and no room where this essential work could be done. Our work in this study was greatly strengthened by assignment of a definite amount of laboratory work in Soils in the new year's catalogue, and we have arranged to use the dairy room when dairy classes are not in session. Mr. Knorr will direct the laboratory work in Soils and I will give the class lectures. This term I also had the Senior Agricultural students in Farm Management. This work is becoming an essential feature of the Agronomy work in all colleges where instruction in Agriculture is given. I fully believe that each Senior who comes to this class should have had at least twelve weeks' experience or apprentice work on a western stock ranch and twelve weeks' apprentice on a western farm where general farming is practiced. I would recommend that we make arrangements to give all Agricultural students in the four year course this apprentice work during the Sophomore and Junior summer vacation periods. That we further urge at least one year's field practice work in a responsible position on some suitable ranch or farm, after graduation, under the direction of the professor of that department of Agricultural work in this College where the student desires permanent employment. There are many calls for farm managers which we cannot fill because we have few students who are fitted for the responsibilities which this work entails. Each farm manager of to-day needs thorough instruction in Animal Husbandry, Agronomy and Farm Engineering, with *plenty* of ranch and farm *apprentice* work unless he has been brought up on a farm and is very familiar with all classes of farm operations. Two correspondents are even now urging me to send them each a farm manager for large ranches in the West and Southwest, and I cannot do it, because our work has not been established long enough to give the boys the training this work requires. Let us plan to do some thoroughly practical work along this line of farm management, for there will be pressing calls for workmen along this line of agricultural work and our schools will be valued and rated by the preparedness of our graduates and their practical efficiency.

Spring Term, 1906. The Agricultural Sophomores come to me in the spring term for class instruction and laboratory work in Field Crops. I know of no text book now written which emphasizes the fundamental principles and gives a classification and discussion of crops adapted to our conditions. I am therefore writing the text which shall combine the lectures and an outline of the laboratory work, which I feel will prove interesting and beneficial to our Agricultural students, in a manner which I desire to place in the students' hands. There is a dearth of text books in all our modern agricultural work. Mr. Knorr

was of great assistance to me in the laboratory work during this Spring term. I had special students this term doing research work in Agronomy.

Special Courses. Beginning the first week in December, the first Short Course work in Agriculture for the farmer boys and girls was inaugurated. Fifty students, varying in age from 18 to 35 years, applied for this work. It proved a success from the start. The course, covering three months—December, January and February—was crowded full of instruction in those lines of study and research work which can be carried at once into the practical work of the home and farm life. I had classes in Field Crops and Farm Mechanics. Two Western Slope girls led the class in term standing in Field Crops; one, Miss Emma Larson, gained a grade of 98 and is deserving of special mention. The second term of this Short Course work will be taken up this present month of December, when I will give instruction in Soil Fertility and Farm Management.

Farmers' Ten Day Course. This work was given the third and fourth weeks in January. You will remember that you granted me two days for grain and forage work and one day for Farm Mechanics work. We were able to secure Prof. W. J. Spillman, Agriculturist for the U. S. Department of Agriculture, Prof. C. A. Zavitz of the Ontario Agricultural College, to lecture on Agronomy subjects and Mr. S. M. Woy, General Manager of the International Harvester Company at Denver, to lecture on Farm Mechanics subjects.

One entire day was given to demonstration work by the students in Farm Mechanics work, Long Course. The forenoon session was given to general discussion and demonstration work of models presented of haystackers, racks, feed racks, gates and poultry houses, with miscellaneous exercise work in iron and steel. The afternoon session the students gave a threshing demonstration, all the work from running the engine to sacking the threshed grain being done by the Farm Mechanics students of the school under the direction of Mr. Smith, Assistant to General Manager J. F. Albright, of the J. I. Case Threshing Machine Company, and Mr. Wm. O'Brien, Superintendent of the College farm. A demonstration with gasoline engines, with a lecture on same, was given by Mr. S. M. Woy, of the International Harvester Company, Denver, and this was followed by a manure spreader demonstration in the field. Each spreader was filled with well rotted barn-yard manure, and this load was scattered in a chosen field on the College farm. The following machines were sent to the College and used in this field demonstration work:

1. New American Spreader, from American Harrow Co.
2. Success Spreader, from John Deere Co.
3. 20th Century Spreader, from Parlin & Orendorff Co.
4. Great Western Spreader, from Smith Mfg. Co.
5. International Harvester Co. Spreader.

After this field work with the spreaders, the farmers were invited to a cleared space adjacent to the Farm Mechanics building, where several thousand dollars' worth of modern machinery, which I had prevailed upon various farm implement companies to loan the College, was placed on display. Representatives of the various manufacturing companies were present and explained to interested questioners the use and efficiency of the various machines.

Farm Mechanics Day was so crowded full of helpful instruction and interest, that I trust you can see your way clear to make it a permanent feature of each year's course for the farmers. Here the manufacturers can get the benefit of the farmer's ideas and criticisms, and the farmer gains a better conception and a keener appreciation of the modern machinery the twentieth century is bringing to his aid.

Chair of Farm Mechanics. One year after I had taken up the Agronomy work with you, when I felt sufficient interest and work had been developed to justify it, I recommended that this division of the Agronomy work be made into a new Chair, coordinately with Animal Husbandry and Agronomy. This suggestion was approved by you and, upon your recommendation, the Board authorized the establishment of this chair, and called Prof. H. M. Bainer, of the Iowa State College, to take charge of this new work in Farm Mechanics. His efficiency he has already demonstrated, and the value of this work is now being realized and appreciated by the people of the state.

Colorado Seed Competition Club. Early in the spring, I sent out instructions to members of our seed competition club for seeding and asked that reports be sent in from time to time. These members numbered several hundred, well distributed over the grain growing sections of Colorado. The bad storms of last month delayed threshing operations and not all the members of the club had been able to thresh when this report was written. I hope to be able to get all reports so I can make the prize awards by December 1st. There will be $400.00 in prizes awarded for the 1906 crop, $400.00 for the 1907 crop, $400.00 for the 1908 crop, and $1,300.00 for the term premium awards in 1908. We hope to enlist the support of the rural teachers at the State Teachers' Association in December, and shall strive earnestly to increase the club to 1,000 members next year. I shall send out a New Year's letter urging each present member to bring in one additional member and plan to make the best possible record with our grains for 1907.

Farm Institute Work. It has been my privilege to assist in Farm Institute Work in the following counties: Arapahoe, Bent, Boulder, Delta, Elbert, El Paso, Conejos, Fremont, Gunnison, Kit Carson, La Plata, Logan, Mesa, Montezuma, Montrose, Otero, Prowers, Pueblo, Rio Grande, Routt and Weld.

I find considerable interest is shown in questions of cultural soil treatment to maintain, or regain and retain fertility, seed selection, the thorough tillage treatment and special crop discussions. I have tried to adapt my discussions to the crop and farm environments of the places where the institutes are held. I am certain a considerable influence of permanent value can be exerted by the Farm Institute movement, looking to better systems of crop and live stock farming in our state.

Correspondence. My correspondence is increasing, but I believe it is to be encouraged if we expect to come in touch with farmers in the state. I want every farmer to feel perfectly free to write me on any farm question and to know that his letter will receive careful consideration in a prompt, ready and courteous reply. I have a plan for a crop correspondence system in connection with my Department which, if adopted, will enable us to receive accurate crop statistical data. Some system is now in operation in all the agricultural states and is the source of reliable information as to the number and kind of crops grown, yield and value, market conditions, etc. This plan I will carefully outline and explain to you before January 1st.

Course of Study. The course of study agreed upon for 1906-'07 was printed in the regular course of study. The only changes I would like to see made I enumerate below:

1. Freshman Year—The time for laboratory work in Spring Term Farm Mechanics extended two hours per week and each student in the Agricultural Course taught to run land levels.

2. Senior Agronomy work in the Fall to consist in research work in Tillage and Cultural Methods of Crop Farming. In the Winter Term, lectures in Agricultural Economics; Spring Term work, Senior year, Research work and class lectures in Farm Management.

I would like very much to have the following post graduate work indicated in the new year's catalogue:

I. The Thorough Tillage System of Farming.

II. Grain Judging.

III. Special Studies in Field Crops.

1. Forage Crops for Colorado.
2. Sugar Beets.
3. Wheat.
4. Oats.
5. Barley.
6. Seed Testing and Germination.
7. Plant Breeding as applied to Field Crops.
8. Study of past and present Market Conditions.
9. Rotation of Crops.

IV. Farm Management.
1. Special versus Mixed Farming.
2. Crop Methods for Irrigated Farming.
3. A Method of Farm Accounts.
4. Handling Labor on the Farm.
5. Extensive versus Intensive Farming.

New Assistant Needed. The teaching work is increasing to such an extent that I feel, before another year, I shall need an assistant to take some of the class instruction work in both the Long and Short Courses. I would suggest that we secure one of Dr. Hilgard's students who has made a careful study of soils in both the arid and humid regions, and who will be prepared to also do the chemical work of both the Animal Husbandry and Agronomy sections of the Station when not engaged in class room instruction.

My plan is to organize the Soils into a department as soon as we get an assistant of sufficient ability, force and experience to carry the work.

The study of the soil is the foundation work in all successful crop farming. My work is increasing to such an extent that I feel I must, another year, have an assistant to carry a part of my class work. I would prefer one thoroughly prepared in Soil Study work, so we can make the division of the Agronomy work along this line later on.

Recommendation of Mr. Knorr. Dr. Aylesworth promised to ask the Board at the June meeting, to advance Mr. Knorr's salary from $600 to $800 per year. He told me later that the Board agreed to advance Mr. Knorr's salary to $800 beginning November 1st. Because of the increased amount of class instruction and laboratory work which I am forced to give Mr. Knorr in addition to his field work, I desire arrangements made at the December meeting to advance Mr. Knorr's salary, after graduation, to $1,200, and that he be made Assistant Professor of Agronomy. He is one of the most practical and thoroughly efficient young men in agricultural work, and unless we recognize his ability and plan *now* for his advancement, I fear we shall lose him, later on. He was offered desirable positions this past summer elsewhere, but I told him if he would stay with us we would take care of him and give him merited promotion.

My field work at the College is broadening and I need his help in the College work as well as in the field station work. Kindly present this matter for me at the December meeting, or at such a time as you may think most opportune.

Special Needs. There are some special needs in the way of apparatus and room which I wish to name in a special report later on. There are calls coming in for special farm management work and Mr. Knorr and myself desire to be prepared to give the desired instruction. We seek to make our instruction

in Agronomy as practical and thorough as possible, so students shall feel it helpful in fitting themselves for farm work under western conditions.

I am grateful to you for the many courtesies which you have extended to me during the year just closing.

Respectfully submitted,

W. H. OLIN,

Professor of Agronomy.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DIVISION OF ANIMAL HUSBANDRY OF THE AGRICULTURAL DEPARTMENT.

Professor W. L. Carlyle,
Dean of Agriculture,
Colorado Agricultural College.

Dear Sir—I herewith submit a report of my work in Animal Husbandry and a statement of plans and needs for the future:

I began work September 1, 1906, and October 1, 1906, you engaged W. H. Riddell, a graduate of this College, Class of 1906, as my Assistant.

I have taught four classes during the Fall Term of 1906:

Senior Class in Feeds and Feeding.

Junior Class in Feeds and Feeding.

Sophomore Class in Breeds of Live Stock.

Sophomore Class in Judging Live Stock.

During the three months that I have been connected with the College I have made three trips, of a week to ten days each, on Farmers' Institute work. At present, one student, W. H. Riddell, is taking post graduate work under my direction, in feeding.

We have fairly representative pure bred animals of most of the leading breeds of beef and dairy cattle, sheep and hogs. We need for class work in the study of breeds, Galloway and Jersey cattle, and Duroc Jersey hogs.

Our great need for efficient, practical instruction is in feeding animals and in feeding operations. The feeds and climate of Colorado are particularly adapted for the production of meat of the highest quality, and when Colorado stockmen become feeders the State will be noted for its large production of animals fattened on Colorado grown feeds, and the meat from these, on account of its superior flavor, will command a higher price than that from the corn belt.

The College should feed on a commercial scale, to enable our students to obtain a practical knowledge not only of the effect of different feeds, but of how to handle and manage stock on a money making basis. They cannot learn this from feeding small lots. We should feed cattle, hogs and sheep in carload lots, and have a sufficient number of carloads of each class to teach our students to be able to judge and select feeding animals on a carload basis, as a means of making a living that will be worth many times to them the studying and judging of a few choice pure bred animals.

For this purpose I recommend that the College feed each year ten carloads of beef cattle, raise and fatten each year one thousand hogs and feed two thousand sheep. The feeding should be conducted to make money. The work should all be done by students working under the direction of the Professor of Animal Husbandry. With such a system of four years of practical work in feeding, coupled with thorough theoretical work in the class room, our students would graduate ready to profitably operate feeding plants and would become leaders among our stockmen.

Few States have as favorable conditions for profitable poultry production as Colorado, yet the entire yearly poultry products marketed in the State will not supply Denver alone for more than sixty days, and one million and a half dollars' worth of poultry was shipped into Colorado the past year. Colorado should not only produce all poultry and eggs needed in the State, but should and could profitably ship several million dollars' worth each year to other States.

The Colorado Agricultural College should keep one thousand hens and produce on a commercial scale eggs, broilers, roasters, turkeys, ducks and geese. In connection with this work, we should establish a course in poultry raising and furnish an opportunity to every boy and girl in the State to learn how to hatch fowls the natural way and by incubators, and the feeding, breeding, fattening and marketing of poultry.

Respectfully submitted,

H. M. COTTRELL,

Professor of Animal Husbandry.

Fort Collins, Colorado, November 30, 1906.

REPORT OF THE DIVISION OF FARM MECHANICS OF THE AGRICULTURAL DEPARTMENT.

Prof. W. L. Carlyle, Dean of Agriculture, Colorado Agricultural College.

Dear Sir—I hereby submit plans for work which I believe advisable to carry out in the Farm Mechanics Department of the Colorado Agricultural College in the future.

While Farm Mechanics has been taught, to a limited extent, in connection with the Agronomy Department for the past two years, it has been organized as a separate Department since July 1st of this year. I arrived here from the Iowa State College the last of June to begin work organizing this new Department.

Shortly after arriving here, I accompanied a party of Farmers' Institute workers to the Western Slope for the purpose of obtaining information as to various state conditions. Since that time I have made several visits to various parts of the state for the same purpose. The remainder of the summer was spent organizing the work of the Department and securing machinery for instructional and experimental purposes.

For the reason that the Department is just being organized, there was no arrangement made for classes according to the College catalogue, other than the work taken up under the Agronomy Department last year. The work as outlined in the present catalogue for the regular course in Agriculture takes up the following:

Freshmen—Woodwork—Fall Term.

Freshmen—Iron Work—Winter Term.

Freshmen—Farm Machinery—Spring Term.

Farmers' Three Months Short Course:

First Year—Farm Machinery, three weeks—Second Term.

Second Year—Farm Mechanics—First Term.

During the first one-half of the present Fall term a special class has been organized in "Farm Motors," consisting of Seniors and Juniors in the Agricultural Course. The larger part of this class are continuing this work for the remainder of this term.

For next year I recommend that we take up the following class work:

Freshmen—Woodwork—Fall Term.

Freshmen—Iron Work—Winter Term.

Freshmen—Farm Machinery—Spring Term.

Sophomores—Rural Architecture—Winter Term.

Juniors—Farm Motors—Fall Term.

Seniors—Special Farm Mechanics—Spring Term.

Farmers' Three Months' Short Course:

First Year—Farm Mechanics—Second Term.

Second Year—Farm Motors—First Term.

Up to the present time we have been able to secure about $12,500.00 worth of farm machinery for experimental and demonstration purposes. This machinery has cost us nothing more than the freight charges from the nearest general agency of the manufacturer to Fort Collins. We will be able to secure several thousand dollars' worth more of sample implements and machines at no more cost than the above, providing we are furnished with enough funds to cover freight charges. Owing to the fact that implement companies are really asking us for an opportunity to place with us sample goods and that our shed room is very limited, it will be necessary to secure funds for more storage room in the very near future. There is no reason why the student who comes here from the farm, as well as the many interested visitors, should not be able to see well kept sample implements and machinery in this department. For this purpose we need room enough for at least $50,000.00 worth of farm machinery.

On account of not being provided with funds for experimental purposes, it is very difficult to outline work of this kind. We have, however, started some investigation work in the following lines, and expect to carry it out as rapidly as the necessary funds can be secured.

Pumping Plant. The College has agreed to furnish material for causing a well and equipping it to develop additional water supply for the College Farm and for an experimental pumping plant. We expect to dig this well on the College grounds with farm help. We now have a pump and have been able to secure a gasoline engine for power purposes, which can be used in connection with this work. This investigation is for the purpose of ascertaining the cost of lifting the water by gasoline, kerosene or denaturized alcohol; also to determine the amount of water necessary for the growth of certain crops and to gain general information regarding this method of securing water. We believe it also advisable to visit various pumping plants throughout the state for the purpose of securing general information in regard to equipment, arrangement, cost, practicability, etc.

Gasoline Engines. On account of the passage of the bill on denaturized alcohol, we believe it advisable to do experimental work with alcohol, comparing it with gasoline and kerosene. At the present time we are conducting a test comparing kerosene and gasoline for power purposes in the gasoline engine. For this purpose we now have seven gasoline engines.

Steam Plowing. Having secured a 25 H. P. Traction Steam Engine, equipped with eighteen plows, we believe it advisable to make investigation concerning the question of steam plowing, its cost, etc. In connection with this work we are anxious to secure such facts and information as may be obtained from various plowing outfits over the state and to place the data thus obtained so that it will be of value to the general public.

Draft Tests. We find that similar implements of different manufacturers vary greatly in the amount of power necessary to operate them. For the purpose of making comparative draft tests we have secured the use of a German Dynamometer from the U. S. Government.

Special. At the present time we have two manufacturers of grain drills making special drills for use under "Dry Farming" conditions.

Another company manufacturing Grain Graders have made us a special grader for grading beet seed, alfalfa seed and various small grains. We believe that the beet seed grading attachment will be of special value to the Sugar Beet Industry. Uniform sized seeds planted in check with a special planter so the beets can be cultivated both ways will certainly aid in the cost of beet production. By uniform size of seed, two can be dropped in each hill, and in case both seeds grow, one plant can easily be removed. Thus the question of beet thinning will be made less expensive.

We also desire to make special study and investigation of beet cultivators, pullers and toppers.

Still another field open for investigation is the "Use of Cement on the Farm," which we desire to take up.

Respectfully submitted,

H. M. BAINER,

Professor of Farm Mechanics.

Fort Collins, Colorado, November 7, 1906.

REPORT OF THE FARMERS' INSTITUTE DIVISION OF AGRICULTURAL DEPARTMENT.

Professor W. L. Carlyle,
Dean of Agriculture,
Fort Collins, Colorado.

Dear Sir—I have the following report to make as Director of Farmers' Institutes. This report covers the period from August 1st, 1905, to November 1st, 1906, and also covering practically all of the institute work that has been done since my appointment as Director.

The total number of Institutes held were 48; total number of sessions, 152; total attendance, 18,615; number of speakers employed from College Faculty, 16; speakers employed outside of the College, 10. With the exception of a few scattering counties in the Eastern part of the State which are as yet very thinly settled, Institutes have been held in practically all of the Agricultural counties of the State and in some of the counties covering large areas several Institutes have been held.

As regular Farmers' Institute work was new to the majority of our agricultural population, our first year's work has been largely of an introductory nature. This is necessarily more expensive work, as it involves sending out enough speakers to practically occupy all of the time of the Institute.

Commencing this fall we have very materially reduced the number of workers sent to each Institute and are seeking to place the work upon a more practical basis by limiting the number of subjects to be discussed and exhausting those subjects thoroughly. Eleven Institutes are being held during the present month, which will conclude our Institute work for the present year, as the Short Course at the Agricultural College, in December, followed by the holidays, will occupy all the time of the men who might be employed in the Institute work.

The cost of the work up to November 1st has been approximately $5,500.00, leaving a balance of about $2,500.00 to pay the cost of the Institute work this fall and early spring. In estimating the attendance at the Institutes, it has in most instances, been based upon count of the number attending the various sessions. During the past year we have succeeded in developing some local talent that can be used to good advantage in the future for Institute work in the field. We should have an appropriation for the ensuing two years of at least $10,000.00 and in the future the work should be confined to those localities expressing a desire for the Institute work. During the past two years we have, in a measure, forced the Institute work upon the people, as we were

compelled to introduce it. Now that the nature of the work is understood, however, I would recommend that Institutes in the future be given only when the people of any locality express enough interest in the work to request one.

By this method some localities will probably secure more Institutes than others, but this can not be avoided. It has been my policy to encourage the holding of Institutes wherever the people are inclined to show any interest whatever in the work.

In suggesting the increased appropriation for the ensuing two years, I do so under the idea that, in the future, members, of the Agricultural Faculty will be unable to give as much time to this work as they have during the past year, owing to the increased attendance at the Agricultural College. This will make it necessary to engage outside workers as other States do, and will necessitate larger expenditures. As a rule where the Institute has been well atended the effect has been good and there seems to be a general demand that the work be continued during the coming two years, provided funds can be secured from the Legislature. I am assured that we will have the co-operation of the farmers and stockmen generally in the securing of such an appropriation as may be necessary. Our ability to cover the large territory that we have and to hold so many Institutes on the small amount of money appropriated, is due to the liberal assistance provided by the railroads, which have generously provided transportation for our workers on practically all occasions, only one railroad having denied this assistance, and in that case half rate was secured. We have reason to hope that this assistance from the railroads will be continued.

At all of the Institutes we have made it a rule to very thoroughly describe the educational work being done at the Agricultural College and the advantages to be had by young men and women in taking an Agricultural Course at the College. We have also endeavored to interest farmers' wives and daughters in the work, and the attendance at all of the Institutes has been about equally divided between men and women. At many points we have been able to hold special sessions devoted to the women entirely, and as a rule we have found them very effective and popular. I believe that the results obtained from the Institutes already held during the period of this report have unquestionably been of great benefit to Agriculture in the State. The continuation of the work can not fail to bring the same benefits to Agriculture in Colorado that have been secured in other States where Institute work was not only new to the Agriculturists of the State, but also to the men and women from the College and elsewhere, who engaged in the work. I feel that we should be congratulated upon the complete success so far attained.

Very truly yours,

FRED P. JOHNSON,
Director of Institutes.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND BOTANY.

To The State Board of Agriculture.

Gentlemen—I have the honor to present the following report of the Department of Horticulture and Botany for the year 1906.

There have been a number of changes in the personnel of the force of the Department during the past year. Prof. O. B. Whipple was transferred in April to the western part of the State, where he has charge of the Western Slope Fruit Investigations. Mr. E. R. Bennett came to us to take charge of the potato investigations in April, Prof. L. M. Paull was secured to take the place left by Mr. Whipple and assumed his duties at the beginning of the present school year. It will thus be seen that the Department has been materially strengthened and its work broadened.

The work of instruction has gone according to the schedule and the interest has been good. There are some changes in the course of study, however, which we hope to see adopted by the next school year.

FRUIT GROWERS' SHORT COURSE.

Arrangements are progressing satisfactorily for the Fruit Growers' Short Course which is to be held in Delta, beginning January 14th and continuing one week. The citizens of Delta County have taken an active interest in the school and give assurance of a large attendance.

WESTERN SLOPE FRUIT INVESTIGATIONS.

This work, which you authorized at your last December meeting, was duly inaugurated last spring. Mr. E. P. Taylor, a graduate of this College, was appointed Entomologist, and O. B. Whipple, formerly assistant in this department, Horticulturist. Their reports will appear elsewhere, but I may say here that the results have far exceeded our expectations. The calls that came to these men by mail and telephone requesting visits of inspection would have taken all of their time had they been fully met. But a number of experiments were undertaken and results have been attained which should be of much value to the fruit growers.

POTATO INVESTIGATIONS.

The importance of the potato crop in the State seemed to warrant the employment of an expert to devote his entire time to its study. The problems concerned are of such a nature that several years must elapse before much can be accomplished. A good start has been made with the work and a number of leading experiments have been outlined for next season.

EQUIPMENT.

The Department is now very well equipped with apparatus. In former reports I have mentioned our needs in the way of new greenhouses and suitable land for orchard purposes. These needs are still urgent.

The development which the Department has undergone in recent years is certainly gratifying to me and I therefore wish to express my appreciation of the liberality and fairness with which my requests of the Board have always been met.

Respectfully submitted,

W. PADDOCK,

Professor of Horticulture and Botany.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

To The State Board of Agriculture:

Gentlemen—I have the honor to submit herewith the annual report of the Department of Mechanical Engineering.

The students in the first and second Sub-freshman years have received instruction in wood working, being taught the ordinary bench work of the carpenter. This is all the departmental work these students get until they reach the Freshman year.

The Freshman students have received instruction in drafting and bench work in wood and, in connection with their shop work, have had text book work bearing upon the subject.

The Sophomores have received instruction in machine drawing, workshop appliances, machine design and special machines. Their shop work has consisted of training in wood turning and pattern making.

The Juniors have taken up the subjects of machine design, principles of mechanism, steam boilers, steam engines, metallurgy and pumping machinery. Their shop work has been in the foundry.

The Seniors have received instruction in gas and oil engines, steam engine design, transmission of power, thermo-dynamics, compressed air machinery, heating and ventilation, railway mechanical engineering, contracts and specifications.

All the work has been accomplished, and, we believe, with direct benefit to those students who have profited by their opportunities. We have used modern methods in the classrooms, laboratories and shops, and while students have much to learn after leaving college, we are confident they will not have to learn over again what has been taught them. The industrial prosperity and activity of the country calls for large numbers of young men trained along mechanical lines and this demand promises to be long continued. The young men from this Institution are measuring up to the requirements of the times and are to be found in many places of responsibility and trust.

The rapid advance in the improvement of methods and machinery has brought about many changes. High steam pressures are calling for stronger and better boilers, and this in turn calls for better steel. Improved tool steels have called for changes in the design and construction of machines and these new machines are capable of turning out work much more rapidly than ever before. The electric drive has been put to many uses not thought of a few years ago, and has a general tendency to hurry up things.

Great discoveries and the rush of modern methods is calling for more from the young men in the way of knowledge of things and affairs, and this Department has tried to keep up with the world's work in the lines required of us, and if the evidence of those students who have made a success of their work counts, then we have done it.

We believe the work of the Department is in line with that of the best schools of the kind, and that our graduates are able to hold their own.

Respectfully submitted,

J. W. LAWRENCE,

Professor of Mechanical Engineering.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF CIVIL AND IRRIGATION ENGINEERING.

To The State Board of Agriculture:

Gentlemen—I have the honor to present the annual report of the Department of Civil and Irrigation Engineering for the past year.

The work of the Department has been hampered by lack of room. The present quarters were outgrown a good many years ago. Though the quarters were a convenience at the time this building, the oldest one on the grounds, was assigned to this Department some twelve years ago, they were even then inadequate, because of lack of laboratory facilities and for instruction in matters relating to irrigation and hydraulics, which requires much more laboratory room. It would have proven entirely inadequate except for the fact that the fields, ditches and reservoirs, streams and mountains of the surrounding country have been used to a great extent as a part of our laboratory equipment. There are more enterprises of this character and more illustrations or irrigation work within a moderate distance of Fort Collins than in any other center. The lack of laboratory room, therefore, forces more attention to outside work, but from the standpoint of teaching, this course has very serious disadvantages. The progress of this State depends so largely upon water that questions of this character are of great importance, but we cannot do what we should, either for our students of for the State without greater facilities of this kind. The requirements of teaching and all programs for recitations do not readily lend themselves to the use of laboratories which may be several miles away. The lack of room has been seriously felt. In the lack of class rooms a makeshift has had to be made to find recitation rooms. Likewise the drafting room has been a make-shift, and moderate sized classes have made it necessary to overflow into adjacent rooms at great inconvenience, as well as under conditions that are not possible for the best work. The fact that we have reached the capacity of the building for instruction has stood in the way of increasing the number of students, although there has been a steady growth.

With the lapse of years there has also been a steady cause of anxiety in the increasing dilapidation of this building. The foundation has settled and the walls have cracked seriously. It is a frequent question as to the safety of the building. Manifestly it cannot be considered as a safe structure for many years longer. If it should be that it is necessary to still occupy this building for some time in the future, I should recommend the construction of an addition or some temporary structure, even a tent, to meet the necessity of additional room. That this building occupies a

central position on the grounds has made us hesitate to recommend temporary additions, unless they could be so built as to be pleasing to the eye. At the same time our necessities are increasing and we must have additional room.

This Department was organized and the course in Irrigation Engineering established in 1890. There had been a Department of Physics and Engineering established in 1887, with Prof. Elwood Mead in charge, and with his resignation in February, 1888, the present head succeeded him. Physics remained attached to the department until 1905.

The Board had recognized from the first the importance which Irrigation and Irrigation Development played in the State and in all the Western States, and that instruction in it was fundamental to the general welfare of the State. It was at their desire and upon their motion, that the original step was taken toward instruction in Irrigation and the establishment of the course in 1890. This was the first course of the kind in this country, and that it has been useful is shown by the record of its students. Since that time many other Institutions have followed this lead and have established courses especially strong in Hydraulics and in Irrigation Engineering, and even eastern schools are giving instruction in this branch. Even from the agricultural standpoint it is recognized that such engineering is the fundamental part of western Agriculture. The eternal problem is to increase the production of our soils, or to render them capable of production. The most necessary element for a plant to obtain is water. In the humid climates of the east this is supplied by the climate, and the problem there becomes largely one of obtaining other elements and the study of chemistry becomes most important. In this region, in the absence of sufficient rainfall, the primary need is for water. The obtaining of water and bringing it to the land is an engineering question, and consequently we find that engineering is of corresponding importance in the west, although not recognized in the east as a part of Agriculture.

The general intent of the Board seems to have been to cover in this course some of the questions relating to Agricultural Engineering, and these have been more or less closely associated. Instruction has been given in Roads, in Farm Irrigation, in Practical Irrigation and Agricultural Hydraulics. The general attempt is to so prepare our students that they shall be qualified to occupy positions of usefulness in the community and in the development of the State.

It is unnecessary to specify the separate studies which are shown in the course of study as given in the catalogue. It may, perhaps, be well to mention that some of these lines of work and study, which have been given in this Department for a number of years and so announced in the catalogue and planned for with the full approval of the Board, are announced by other

Departments of the College, thus making a duplication of work. If it be the intention of the Board that this duplication should exist, it is only proper that it should be clearly understood and expressed.

The work of a College such as this is largely judged in its collegiate work, by the character of the students we turn out and the benefit which they have received, and the training either in discipline or in special work. A number of years is required for a student to show his training and to find his place. Sometimes a good many years are required. It is always a matter of interest to observe the career of students, and so some record has been made from time to time of the work of former students, especially those who have had instruction along the line of irrigation. The following list is therefore only a partial one, showing the work of many of those who have had instruction in Irrigation Engineering. It is a list in which the College may take pride. The first figure being the year of their graduation, the first place being the place they came from. The list is incomplete. Many of those who have taken the course have gone into other occupations, some are dead, and the addresses and history of some have not been well known.

1892. C. W. Beach, Fort Collins. Graduated from the University of Illinois, 1893; special gaging work for the Colorado Experiment Station; mining surveyor, Victor; in charge of the river records and surveys for the Great Plains Storage Co., Lamar, from Twin Lakes to the State line, 1896-1904; Practicing engineer Arkansas Valley, in charge of considerable construction; Deputy State Engineer, 1905.

1892. Frank Beach, Fort Collins. Special student of the University of Nebraska; Supt. New Mexico Sub-Station at Las Vegas; Of the San Luis Valley Sub-Station, Monte Vista; Prof. of Agriculture and Irrigation Engineering, Montana Agricultural College; Farmer and County Surveyor, Las Animas; Farmer, Fort Collins.

1892. L. L. Stimson, Greeley. Special work for the Experiment Station, 1893; Practicing irrigation engineer, Greeley; County Surveyor of Weld County, several terms; City Engineer, Greeley; as such, had charge of the construction of extensive improvements to the city water works during his term; Surveyed and constructed many of the large reservoirs in Northern Colorado, the Jumbo, Empire, etc.

1892. Porter J. Preston, Longmont. In charge of canal rating and river gaging, State Engineer's office, 1893-'96; Engineer, Pawnee Pass Reservoir Co.; In charge of river service in the Arkansas Valley; Construction Engineer, Fort Lyon Canal enlargement; Supt. of the Fort Lyon

Canal (110 miles long), Las Animas, for several years; Deputy State Engineer, 1903-'04; Construction Engineer in charge of canal system and reservoir, Lewiston, Ia.

1893. J. D. Bloomfield, Meeker. Assistant in Irrigation Engineering Experiment Station, Irrigation Engineer, Greeley; Took charge of the Phyllis canal, Nampa, Idaho, organizing and making a financial success of it in 1894-1904; Cashier of the newly organized Citizens' State Bank, Nampa, Idaho.

1893. S. Boothroyd, Arkins. Assistant City Engineer, Fort Collins; Student at Chicago University; Professor at Mt. Morris College, Ill., and at Bellvue College, Nebraska; Assistant Astronomer Lowell Observatory, Flagstaff, Ariz.; Assistant Prof. Engineering, Fort Collins; Assistant Mechanics, Cornell University, Ithaca, N. Y.; Summers in charge of a party on the International boundary survey, between Alaska and Canada.

1893. R. F. Walter, Fort Collins. Irrigation Engineer for a number of years, at Greeley; County Surveyor, of Weld County; City Engineer, of Greeley; Planned and constructed many irrigation ditches and reservoirs, Engineer Reclamation Service 1902, and has been promoted to Division Engineer in charge of South Dakota, and as such is responsible for all surveys and construction of the Belle Fourche Project, S. D.

1895. J. B. Balcomb, Russell, Kan. Practicing mineral surveyor in Colorado, Engineer of various mines and in charge of various hydraulic constructions and mining work in Palo Alto, California.

1895. Henry Calkins, Harris. Assistant Civil Engineer, Molly Gibson Mine; Medical student, Denver; Practicing Physician, Leadville.

1895. E. P. Cooke, Dowagiac, Mich. From responsible position in Iowa, and now connected with the construction and supervision of a large power plant in California and Nevada.

1895. L. B. Curtis, Denver. For several years Assistant Engineer, having charge of the construction work of the Denver Tramway Co.; Engineer on hydraulic projects, including New Century Mining Company, at Gore Canon; Construction Engineer of 115 mile power transmission plant, from California to the Mining Camp of Nevada, making a record in construction.

1895. Geo. W. Nelson, Denver. Has been assistant Superintendent of mines at Grand Forks, B. C.

1896. H. F. Alps, Loveland. Assistant Meteorologist, Experiment Station, Fort Collins; Observer of the U. S. Weather Bureau, Nashville, Tenn.; Lewiston, Idaho, and Reno, Nevada.

1896. R. W. Hawley, Fort Collins. Assistant Supt. Nampa Canal, Idaho; Assistant Engineer of the Western Homestead Co., Albuquerque, N. M.; Assistant Irrigation Engineer for gaging in the Arkansas Valley for the Colorado Experiment Station; Gauger for the State Engineer's office, Denver; On topographical survey in the Reclamation Service, Supt. of the Carson Sink Canal, Carson City, Nevada.

1896. G. S. Norman (Colored), Hamilton, Ohio. Became 2nd Lieut. 8th Inf. in the Cuban war; Instructor in mathematics Bluegrass Normal and Industrial Institute, Keene, Ky.; Instructor in Mathematics and Agriculture, Agricultural and Mechanical College, Normal, Ala.

1896. R. W. Sears, Rye, Colo. Principally associated with stock interests, though also with some irrigation developments.

1897. A. J. Harris, Fort Collins. Entered the regular army as 2nd Lieut. during the Cuban war, Promoted to Captain —— Inf., stationed at the Philippine Islands.

1897. R. S. Gray, Wyoming. In public Service in the P. I., Deputy Division Supt. of Education, Iligan, P. I.

1897. D. J. Richards, Salida. Enlisted during the Spanish war, in public service, since Deputy Post Master, Manila, P. I.

1898. H. O. Brown, Salida. In business with his father and then on the Engineering corps of the D. & R. G. Ry.; Now Engineer, Los Angeles, California.

1898. R. C. Calloway, Livermore. Foreman of the College farm, Fort Collins; Farmer, Bellevue, Washington.

1898. F. S. Hotchkiss, Hotchkiss. Farmer and Irrigation Engineer, Hotchkiss, Colorado.

1898. Amos Jones, Canon City. Assistant Engineer Crystal River Railway; Assistant in Engineering, Agricultural College, Fort Collins; Entered Reclamation Service in charge of topographical surveys in Nevada; Special Deputy from the State Engineer's office in charge of Arkansas River distribution; Civil Engineer, Stockton, California.

1898. C. E. Swan, Delta. Has been connected with the Engineering Department of the U. P. Coal Company, Rock Springs, Wyo., from a short time after graduation. Now

is principal assistant engineer and has charge of the surveys of many mines in Wyoming and Colorado.

1898. M. D. Williams, Victor. Assistant Engineer, West Gallatin Irrigation Co., Montana; On the Short Line Railroad Survey; Pike's Peak Power Co., where he met with a serious accident; Especial work in the Experiment Station at Fort Collins; Engineer of the Kuykendall Co., Saratoga, Wyo.; In stream gaging and survey with the U. S. Reclamation Service, Arizona and Oregon; Practicing Irrigation Engineer, Klamath Falls, Oregon.

1899. Frank Corbin, Fort Collins. Succeeded to his father's interest in business in the firm of Corbin-Black Lumber Co., Fort Collins.

1899. N. M. Fitch, Denver. Has been in the engineering party of the railroads in Texas and Missouri since graduation, and is now resident engineer of the T. & O. Ry., Ada, Indian Territory.

1899. L. C. Hall, Canon City. City Engineer, Canon City, in charge of extensive sewer improvements.

1899. W. R. Headden, Fort Collins. In the Director's office of the Experiment Station; Graduated from Renssalaer Polytechnic Institute, Troy, N. Y., and is now an instructor therein.

1899. J. C. Mulder, Holland. Entered the Civil Service and is now Provincial Supervisor, Province of Bohol Tagbilaran, P. I.

1900. J. A. Stump, Canon City. Instructor in the Engineering Department of this College for several years, then a student of law at Ann Arbor and is now a practicing attorney at Canon City.

1900. T. M. Donelson, ——————. Principally in engineering parties on railroad work and now assistant engineer on the Mexican Central Railroad at Aguas Calientes, Mexico.

1900. E. C. McAnally, Fort Collins. Has been county surveyor of Larimer county and City Engineer of Fort Collins for several terms. Constructed the scenic road up the Big Thompson Canon to Estes Park; also had charge of the construction of the Fort Collins water works, which cost over $200,000.

1901. Jas. H. Andrews, Fort Collins. Student at Columbia University, N. Y. In charge of location surveys on the Grand River canal at Lulu Pass; In charge of the trestle and sewer work for the Great Western Sugar Company at Fort Collins in 1905; in charge of extensive railway improve-

ments on the C. & S. between Longmont and Fort Collins; Instructor in Department of Civil Engineering, Fort Collins, and post-graduate student 1906.

1901. A. Jacob, Antonito. Assistant in stream gaging and seepage measurements for the Experiment Station; On the Engineering force of the Great Plains Co., at Lamar; Assistant in the State Engineer's office 1903-4; Practicing Engineering, Denver.

1901. G. B. Stannard, Fort Collins. Assistant Engineer in the coal mine surveys of the Colorado Fuel & Iron Company for a number of years. Now a practicing engineer in Denver.

1902. L. E. Cattell, Ohio. Has been steadily in railroad employment in engineering parties in Ohio since graduation.

1902. Oro McDermith, ————. Fellowship in the Agricultural College, and also served as instructor. Assistant in the U. S. Reclamation Service stream gaging and topographic surveys; now in charge of one heading of the Gunnison Tunnel, Montrose, Colorado.

1902. Oliver Pennock, Bellvue, Colo. Assistant in surveys for Mr. J. C. Ulrich on the Grand Valley Canal at Lulu Pass. Permanent address, Bellvue, Colo.

1902. R. E. Richardson, ————. Assistant in special work of the Experiment Station; Assistant Engineer on the construction of Lake Reservoir for the C. F. & I. Co., at Leadville; Practicing Engineer, Delta; Surveyor and practicing engineer, Longmont.

1902. Harry True, Nepesta. Had a fellowship and acted as instructor in the Agricultural College; Assistant in stream measurement State Engineer's office, Denver; Assistant Engineer Panama Canal, under Civil Service, in 1905-06; On reservoir surveys at Sterling.

1903. C. E. Davis, Canon City. Deputy City Engineer, Canon City.

1903. D. D. Gross, Greeley. Draftsman in the Engineer's office of the Denver Union Water Company, Denver.

1903. R. P. Jackson, Denver. Principal assistant in the State Engineer's office 1903-05; Now in the Engineering force of the American Smelting Co., Salt Lake City.

1903. W. A. Lamb, ————. Assistant in gaging for the Experiment Station; Assistant in stream gaging U. S. Reclamation Service in Northwestern Colorado; Now permanently connected with the U. S. Reclamation Service.

1903. R. C. Murphy, Glenwood Springs. Surveyor at Glen wood Springs.

1903. J. A. Phillips, Fort Collins. In the engineering party on the Grand River Canal; With the Great Western Sugar Company at Fort Collins and Longmont in the development of lime quarries.

1904. H. V. Hubbell, Fort Collins. Assistant to the Consulting Engineer for Colorado in the Kansas-Colorado suit, in charge of stream measurements in Kansas 1903-04; In gaging near Pike's Peak in 1905; Irrigation Engineer, Longmont, and now Engineer on the Western Pacific Ry., in Utah.

1904. Ralph Parshall, Golden. Instructor in the Agricultural College; Charge of survey of a railroad now constructed in the Arkansas Valley; In charge of the students' Field Camp in 1905 and 1906.

1904. Howard Sneddon, Salida. In charge of gaging on the upper Arkansas River for the Consulting Engineer for Colorado in the Kansas-Colorado suit; Now a railroad engineer in New Mexico.

1905. P. J. Mulder, Holland. Engineer for the ——— ——— Company, in charge of construction of a dam near Portland, Oregon.

1906. R. L. Cooper, New Windsor. On surveys for the Great Plains Company at Lamar.

1906. J. C. Counter, Brighton. On surveys of reservoirs near Julesburg, Colorado; Now Engineer for the North Poudre Irrigation Co., Fort Collins.

1906. Geo. M. Neel, Greeley. Assistant Engineer Central Colorado Power Co., Boulder, Colo.

1906. Littell Snively, —————. Engineer for the North Poudre Irrigation Company, Fort Collins and Wellington; Appointed Assistant Engineer U. S. Government, under Civil Service October, 1906, for service in the Philippine Islands.

G. L. Swendsen, a graduate of Harvard College, took special instruction in the summer of 1898. Professor of Engineering in the Utah Agricultural College; in charge of the Utah division of the Reclamation Service, and now Division Engineer, Salt Lake City.

E. P. Sandsten, from Wisconsin, a graduate of the University of Wisconsin, took part in some water and crop development in Minnesota and Wisconsin. Now in the Wisconsin Experiment Station.

L. G. Carpenter,

Professor Civil and Irrigation Engineering.

Dear Sir—I submit herewith the semi-annual report of the work done as Assistant Professor in the department of Irrigation Engineering. The summer was spent in the Grand Valley upon the investigation of the seepage problem in that valley.

On August 27th the start was made for the field camp at Estes Park, and two weeks were spent with the Senior Civil Engineers of this College. We were camped at timber line on the western slope of "Flat Top" and, although the weather conditions were not favorable, we succeeded in completing the triangulation of a line for a tunnel from Grand Lake in Middle Park to Willow Creek in Estes Park.

During the three months of the Fall Term just closed, the following classes have been taught:

Senior class in Hydraulics.

Junior class in Strength of Materials.

Sophomore class in Photography.

Senior Civil Seminar has also been under my direction.

The afternoon work in the Testing Laboratory was hampered on account of the delay in receiving the parts of the testing machine sent away for repairs; otherwise the work done by all the classes was good and fully up to the standard.

Respectfully submitted,

E. B. HOUSE,

Associate Prof. Irrigation Engineering.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY.

To The State Board of Agriculture.

Gentlemen—I have the honor to present the following report from the Department of Zoology and Entomology.

The subjects taught in this Department now are Elementary Physiology, Advanced Physiology, Elementary Entomology, Advanced Entomology, Animal Parasites, Histology, Embryology and Evolution of Animals.

The Elementary Physiology is given to all first year preparatory students who do not have passing grades in this subject from accredited high schools.

The Advanced Physiology is taught to the Sophmores of the Agricultural, Horticultural and Domestic Science Courses, and to the Seniors of the Normal Course.

The afternoon laboratory work which used to be given with the Physiology was cut out when the Veterinary Course was introduced. While this is all right for the young men, some arrangement should be made for laboratory work for the women.

Zoology is taught to the students in the Agricultural and Domestic Science Courses. A special effort is made to give the student a good general knowledge of the important types of structure, and the development of the various organs and tissues found in animal bodies, and also to show the relations that exist between these organisms and their environment.

Entomology deals with the insect world and is only required of those students that take the Agricultural or Horticultural Courses. The first term in this subject is practical in its aims, only so much of the structure and general life habits being given as is necessary for an intelligent use of remedies and preventative measures. Two terms of advanced work are also offered to those students who wish to specialize along the lines of either economic or systematic Entomology. So far, the Department has not been able to supply the demands for trained Entomologists and those who have taken our advanced work in Entomology have been quickly picked up to fill positions in various parts of the country. The large systematic collection of insects, and the good scientific library that we now have, are an essential basis for this work.

The lectures to Juniors in the Agricultural and Horticultural Courses upon Animal Parasites, deal with economic species that attack domestic animals either externally or internally, the habits, symptoms and remedies being given in each case.

Histology, which is a study of the tissues of the body, is also taught to the students taking the Agricultural and Horticultural

Courses. So far as possible, the student is taught to prepare the tissues he examines, but the Department has on hand a large variety of tissues in permanent mounts for students' use. The subject is a most interesting as well as a most necessary one for a proper understanding of the organs composing animal bodies.

The lectures in Embryology to Seniors of the Agricultural and Horticultural Courses aim chiefly at laying a foundation for the understanding of the laws of heredity, while they also give a general idea of the first steps in the development of all animals, beginning with the process of maturation and fertilization.

The lectures upon Evolution (or development) of animals are given in the Senior year as a sort of fitting climax to what has gone before in this Department. The theory of Evolution as propounded by Darwin, with the evidence for and against it, and the laws of heredity and variation are discussed, and to make the lectures more easily understood, they are illustrated with numerous lantern slides.

MUSEUM.

The College Museum is now in roomy quarters, but, for lack of funds with which to obtain specimens, it grows very slowly. The recent purchase of over 100 pieces of pottery from the Cliff Dwellings of Montezuma County is by far the finest single acquisition that the museum has had for a long time. The museum collections are unduly crowded now for want of sufficient case room. Mr. L. C. Bragg is in special charge of the museum, and has added many specimens from his own collecting during the year, but I have had to keep him busy in entomological work much of the time.

OUTSIDE WORK.

Much of the time of the head of the Department is required in attending Farmers' Institutes and Horticultural meetings, and in investigating insect depredations in the State. As a result, it has become necessary to throw the teaching of the Department more and more upon the first assistant, Mr. S. A. Johnson.

The work of Miss Palmer as artist in this Department is extremely helpful, especially in my study of injurious insects.

Very respectfully submitted,

C. P. GILLETTE,

Professor of Zoology and Entomology.

Fort Collins, Colorado, November 8, 1906.

REPORT OF THE DEPARTMENT OF CHEMISTRY AND GEOLOGY.

To the State Board of Agriculture.

Gentlemen—I have, in compliance with the requirements of the State Board of Agriculture, the honor to present the following statement of the doings of the Department of Chemistry and Geology since my last report and of its present condition.

The teaching required of the Department has materially increased within the past two years, because it has been necessary to give more time and consideration to the requirements of students taking special courses.

The Department has carried out the work prescribed in the catalogue, adhering faithfully to the courses as laid down. Some changes have been made by other departments in the amount of chemistry required in their special courses, adding somewhat to the work of the Department of Chemistry. The amount of our teaching work has, partly due to this fact, increased till we have at this time ten schedule and twenty laboratory hours weekly, which, in the spring and winter terms, will be further increased by ten schedule hours, making twenty schedule and twenty laboratory hours weekly.

The standard of work in the Department has been maintained as heretofore, but we have not been able to advance it as we would be pleased to do. Changes in the course, extending the required amount of work, have not seemed advisable; in fact, they have not seemed permissible under the obtaining conditions. We have, however, tried to keep fairly well abreast with the advances in this subject by the introduction of new text books whenever it has seemed advisable, and we could do so without inconveniencing others.

While I would be greatly pleased to be able to very materially extend the course, both in the class room and laboratory work, I am still of the opinion which I expressed two years ago, i. e., that under the present conditions it would be of very doubtful advisability.

Our facilities for teaching chemistry are good. If our students had the desire and time to prosecute the study of this branch of science, we are in position to offer them excellent opportunities to prepare themselves for advanced work, particularly in those lines pertaining to Analytical Chemistry.

I have no requests to make in connection with the carrying on of the work of the Department.

The building under my charge is in good condition. The only thing, probably, to which I should call your attention is the condition of walls, which, in the course of the nine years that the building has been occupied, have become very black, due, largely, as I believe, to coal dust. The radiators are not provided with any device to divert the current of heated air from the walls or to catch the dust; consequently, the heated air, with its burden of dust and dirt, sweeps against the walls from the radiator to the ceiling, leaving the dust to mark its path. These walls can not be washed. We have tried this with very bad results. The only thing that can be done with them that will probably give continued satisfaction is to paint them, so that they can be washed and in this way be kept clean hereafter.

Respectfully submitted,

WILLIAM P. HEADDEN,

Professor of Chemistry and Geology.

Fort Collins, Colorado, November 8, 1906.

REPORT OF THE DEPARTMENT OF DOMESTIC SCIENCE.

To The State Board of Agriculture.

Gentlemen—The following is the report of the Department of Domestic Science for the fiscal year just closed. As far as was possible, the work has been prosecuted in accordance with the outline scheduled in the catalogue. An intenser interest has been manifested in the Department as a whole than ever before.

We regret that more young women do not take the regular four years' course; however, the young women who are enrolled in the College in any of its departments take an unusual interest in the work. Excellent work has been done by the young women the past year. The only woman graduating in the regular course, Miss Edna Garbutt, secured a scholarship in the Department of Literature and History.

When this class were Freshmen the standard of the College was raised one year. This necessitated the taking of another Freshman year by the class. Most of the women dropped out, hence the lack of women in the 1906 class. There were three Normal students who finished the two years' course prescribed for them, and they, with all other women graduates of the College who so wished, secured positions. Eight young women of the Second Year Normal Class are candidates for graduation.

Some work in regard to new buildings for this Department has been done. While there is nothing tangible to present in the way of definite sums of money being available, at the same time considerable encouragement has been received.

The Department has long since outgrown its present quarters. But for the courtesies shown by Dr. W. R. Thomas and Professor Paddock's Department, I do not see how our work could have been carried on successfully.

I am sure that your Honorable body realizes the needs of the Department, and we feel sure that, whenever you can, you will aid us in securing more comfortable and commodious quarters.

I would recommend that Miss Anna M. Tuttle be given a scholarship.

In regard to special expenditures, I think the Purchasing Committee will handle that according to the best interests of the College.

Respectfully submitted,

THEODOSIA G. AMMONS,

Professor of Domestic Science.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF VETERINARY SCIENCE.

To The State Board of Agriculture.

Gentlemen—This department gives instruction to students in the Agricultural, Domestic Science and Short Courses. The classes are all larger this year, the students are a better average, and the quality of work done, so far, is superior in every respect.

PRESENT QUARTERS INADEQUATE.

We have outgrown our present quarters, and it was found necessary to seek room for the Freshman class in another building. This was unfortunate and was attended with much inconvenience, as the models, charts, skeletons, etc., needed in this class were also necessary in our own rooms for the other classes.

The class in Bacteriological Laboratory is larger this term than usual. Our Laboratory consists of a table along one end of our main class room. This limited space, combined with our meagre equipment, made it necessary to divide the class of fifteen into two divisions, they receiving one-half of the work laid down in the curriculum.

In this Department, as much, or possibly more, than any other, does the practical in education especially appeal. It is of small value to farmer boys to merely discuss the structure of the animal body, the dressing of wounds and animal castration. They must get out and not only see these things, but take a hold and do with their own hands. Our work in Clinic and Dissection, beginning with the winter term, will find us poorly equipped for this practical work. The dissection room has been practically abandoned, on account of being too small and because of the unsavory odors which reach the library above. To use the stock pavilion would be to practically monopolize it for the term. In order to make complete dissections, the cadavers must be kept over for several days, and would be in the way of other classes. The worst feature of it is not the inconvenience, to student and instructor, but rather the fact that we may not be able to maintain the high standards of work hoped for.

DEMANDS FOR A VETERINARY COURSE.

The meat inspection law, recently enacted by the Federal Government, has caused an unprecedented demand for qualified Veterinarians. Such a course established in this school would no doubt be very popular, and would bring to our College a large number of desirable students. If started, however, it should be on a very high plane. The American Veterinary

Medical Association has fixed a high standard for eligible graduation. The days of the "hoss doctor" are few and his destiny is oblivion.

Every College, if it would approach the ideal of the American Association, must see to it that the terms "Gentleman," "Scientist" and "Veterinarian" are synonyms.

An estimation of the probable expense of starting a Veterinary Course has been placed in the hands of President Aylesworth. While my fondest wish is, and my highest ambition all the time has been, to see such a Course established in this Institution, yet I insist that it would be unwise to start it until it can be launched off on such a pretentious scale as would redound to the credit of the College as a whole. The first essential in this respect would be an appropriate building.

I respectfully request that the salary of Dr. Newsom be raised to an amount more nearly commensurate with his ability and services rendered. His work has been very satisfactory.

The Federal Government is bidding for competent Veterinarians at a salary beginning with twelve hundred dollars per annum. We can scarcely hope to keep a desirable man at a less figure.

Respectfully submitted,

GEORGE H. GLOVER,

Professor of Veterinary Science.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF PHYSICS.

To the State Board of Agriculture.

Gentlemen—I have the honor to report that thet past year has been a very successful one for this Department. The work of some classes was rendered difficult by the lack of sufficient lecture room and laboratory quarters, but the students have responded cheerfully and heartily with the instructors for thoroughness in theoretical knowledge and in laboratory practice.

The term just closing has been severe in its demands on the teaching force of the Department, caused, in part, by the natural growth manifested in the increased number of courses offered, in part by the very large enrollment. The latter made the formation of three laboratory divisions in the Sub-Freshman work imperative and necessitates the meeting of laboratory classes continuously from half past one to six P. M.

All classes are showing good interest and the general spirit of the students is of the best. They respond readily and cheerfully to all reasonable requests for work and show a pride in their results that is very gratifying.

Better instruction in all classes has been made possible by thoroughly overhauling the demonstration and laboratory equipment. Many pieces of sorely needed apparatus have been constructed and a system of prompt repair of breakage, wherever possible, keeps all apparatus at high efficiency. Our equipment is gradually rounding toward a well balanced arrangement, but it is still deficient in some special lines, notably Mechanics and Light.

The improvements made in the late summer for better ventilation are very good, provision has been made for installing a fan that will furnish a positive quantity of fresh air as soon as power is available for driving the motor. This promises to solve our problems in ventilation.

The teaching force of the department is striving earnestly to be able to meet the increasing demands that must necessarily be put upon it by the rapid growth of the College, and, in hearty co-operation with the other departments, is working for the highest standards of character and scholarship.

Respectfully submitted,

CHAS. A. LORY,
Professor of Physics.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF CONSTITUTIONAL HISTORY AND IRRIGATION LAW.

To the State Board of Agriculture.

Gentlemen—The regular work of this Department has proceeded in a most satisfactory manner since the date of my last report. Covering five important lines of study in the Junior and Senior years—Advanced History, the Constitution of the United States, Political Economy, International Law and Irrigation Law—constant study and research are required in order to be able to present to the respective classes the latest and most advanced developments in each one of these topics.

The summer vacation was spent in attending the various Teachers' Normal Institutes held throughout the State, and in presenting to these assemblages of educators the claims of industrial education upon the youth of Colorado. Formal lecturers on historical topics, and informal addresses on industrial, constitutional and other subjects which were being considered by the different Institutes were given. From one to four addresses were made to each of the Institutes. The value of this work, which last summer required 3,700 miles of travel, lies in the fact that it keeps the public school teachers of the State in touch and sympathy with the work of the College.

A few words as to the relation of the general work of the Department to the student body, and of its important bearing on the future of its graduates may not be out of place in this connection. While the special duty of the College is to impart an industrial education, no institution maintained by public funds does its whole duty to its students that fails to give adequate instruction along lines that promote good citizenship and impress the civic responsibilities that will devolve upon them when they arrive at the full stage of manhood and womanhood. More than any other, the industrial classes, for whose special benefit this class of colleges was created, and on whom rests the stability of the republic and the future of free institutions, need a knowledge of the constitution of their country; of the system of government and of laws that have grown up under it; of the relation that the nation has borne and should continue to bear to foreign governments; of the influence that such economic questions as markets, transportation, taxation, public expenditures and tariff regulations have upon their personal prosperity, as well as upon the prosperity of the nation. In no other manner can high ideals of citizenship, and of civic uprightness be impressed upon the youth of the State, and as this duty is well performed, so will this College, and all similar

institutions, become influential factors in promoting the welfare of the Commonwealth, and the future greatness of the Republic.

In the arid region, a knowledge of irrigation institutions, of the laws, customs and usages of the distribution and administration of water, is especially necessary for the Agricultural and Engineering classes. There are errors in the past that remain to be corrected; there are problems rising that must be determined in the future, and as these are adjusted wisely, justly, equitably, so will the Agricultural and Horticultural welfare of Colorado be placed on a more prosperous and substantial basis. Hence the intimate relation of the study of irrigation institutions to the Agricultural and Engineering Departments of the College—wise legislation as to water titles, and an efficient and equitable water administration being absolutely essential to all material growth and prosperity in the arid region.

In conclusion I have to express my knowledgements to the President and to my associates in the Faculty and to the members of the Board for their constant courtesy and assistance.

Very respectfully submitted,

W. R. THOMAS,

Professor of Constitutional History & Irrigation Law.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF LITERATURE AND HISTORY.

To The Honorable Board of Agriculture:

Gentlemen—The Department of Literature and History completes another successful year with this report. Attendance upon classes has been large, and the work characterized by increased earnestness on the part of students.

By permission of our College President, and your Honorable Board, I have spent four months of this year in travel in Europe, leaving my classes for the last month of the Spring term in charge of my sister, Mrs. F. G. Willson, of Urbana, Illinois, who completed most satisfactorily the work of the Department for the year. I return to my place this fall with renewed interest, and with the benefit of the inspiration which the student of History and Literature never fails to find in the Old World.

The lecture course for young women supplied for the last three years by this Department is continued, and our thanks are due to the following friends who have given helpful programs since my last report:

Miss Ruth Paxson, Chicago, "In College, What? After College, What?"

Dr. Frank Bayley, Denver, "The Best Gifts."

Miss Olaf Krarer (A native Esquimau), "Life in the Frozen North."

Mrs. Helen L. Grenfell, Denver, "One Part of a Girl's Life."

C. A. C. Girls. A Symposium.

Dr. Louise Hannum, Greeley, "Some Literary Teachers."

Department of Music and Elocution, C. A. C., Recital.

May I call your attention to the fact that the number of women students who select our four years' College course is constantly decreasing. I believe that as soon as funds will permit, this course would be enriched by the addition of more extended work in Modern Languages, and such general science and culture courses as are particularly desired by young women who seek higher education for well developed womanhood. With the additional attraction offered by our courses in Domestic Science, we ought to furnish the most attractive course for women in the State, but while enrollment of women in the four years' courses of other Colleges has increased remarkably during the last few years, we find that in this course our attendance has steadily decreased until this year only four women students, two juniors and two freshmen, are enrolled in our regular four years course.

I wish to express my appreciation of the assistance supplied to my Department this year through the scholarship plan. Miss Garbutt is giving excellent service, both as instructor and office assistant.

May I also express the satisfaction I take in the increased library facilities. Every improvement in the library is an enlargement of every Department of the College.

With hearty appreciation of many courtesies received during the year from our College President and the Board of Agriculture. I am, Very respectfully yours,

VIRGINIA H. CORBETT,
Professor of Literature and History.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

To The State Board of Agriculture:

Gentlemen—The work of this Department for the past year has comprised classes as follows:

(1) Winter Term, 1905-06.

One hundred and ninety-nine students enrolled in Differential Calculus, Descriptive Geometry, Plane and Spherical Trigonometry, Plane Geometry, Elementary Algebra and Arithmetic and reciting in ten divisions.

(2) Spring Term, 1906.

One hundred and sixty-seven students enrolled in Integral Calculus, College Algebra, Solid Geometry, Elementary Algebra, and Arithmetic, and reciting in nine divisions.

(3) Fall Term, 1906.

Two hundred and fifty-one students enrolled in Plane Analytics, Descriptive Geometry, College Algebra, Plane Geometry and Elementary Algebra, and reciting in ten divisions.

The full program of the catalogue has been accomplished with a good standard of scholarship. The general attitude of the students is for hard work, while the number of failures is not above the average.

My summer in the University of Chicago gave me an opportunity to compare our schedule and standard of work with many other schools in the country. As a result of this investigation it is my purpose to make a few changes in our course—changes toward a more concrete application of the advanced problems of mathematics to physical and engineering science.

I have to report the harmonious co-operation of my two assistants, and beg to express my appreciation to the President and Board for their continued courtesies.

Respectfully submitted,

S. L. MACDONALD,
Professor of Mathematics.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF RHETORIC AND COMPOSITION.

To The State Board of Agriculture:

Gentlemen—In compliance with your order of November 3, 1906, I hereby submit my report for the year ending November 30, 1906.

GENERAL MENTION.

The work of the Department from November 30, 1905, to September, 1906, I can not report as I did not come to the College until September of this year.

During the first term of the college year 1906-1907, we have been making special effort to get in touch with the work and with the general preparation of the students. We have been somewhat handicapped by large classes. The following schedule gives the number of classes and the number of students in the Department during the present term.

Two (2) Sub-Freshman Classes in Lockwood and Emerson's Elementary Rhetoric. Number of students ... 82

Two (2) Freshman Classes in Baldwin's College Rhetoric. Number of students ... 85

One (1) Senior Civil Engineering Class in Creighton's Logic. Number of students ... 3

In connection with the work of this Department should be mentioned the work in Interpretative Reading, by Miss Baker. The course is for the First Sub-Freshmen only. Half the time given to it is taken from History and half from Rhetoric. For further information concerning this course, see the report by Miss Baker.

FIRST SUB-FRESHMAN CLASS.

The First Sub-Freshman Class is composed of students of very unequal preparation. Some of them have come from good country schools, some have come from poor country schools, while some of them have had a year or more in High School. Consequently the best work can not be done. A considerable part of the time that should be devoted to Rhetoric must be given to Grammar. Either the students should be kept out until they have mastered Grammar, or a course in the study of Grammar should be offered. It is hardly fair to keep the students that are well grounded in Grammar back with those who need another year of work in the subject.

The majority of the class is doing good work. Realizing that the ability to speak clearly and forcibly is almost a necessity, the class has organized a debating society, in which every member will

be on the program once a month. The meetings are held every Friday at 11:15 a. m.

FRESHMAN CLASS.

There are eighty-five students in the class. This number includes the Junior ladies from the Domestic Science Department. The program schedule gave us but one hour for the whole class. The recitation room is too small to accommodate so large a class. About half the number agreed to come to class at 7:30 a. m., so the class was divided. One division recites at seven-thirty and one at eight-fifteen. Although the recitation periods are a little short, fairly good work has been done.

We find that the graduates of good High Schools are better prepared than the students who have come up through the preparatory course here. The students from the High Schools have had much more work in English. The text used in this class is for University rather than College students, and is too difficult. We believe that a simpler text, with more practical work will give better results and increase the efficiency of the Department.

Spelling in all classes is poor. Systematic work needs emphasis. To that end every student is working up a long theme (50 to 125 pages), on a subject of special interest to the student making the investigation. Among the subjects for treatment are the following:

The Development of Irrigation in Colorado.

The Development of Hereford Cattle.

The Summer Tourist.

The Combustion Engine and Commerce.

Reclamation of Worn-out Farms.

Transportation and Commerce.

Four months of systematic work will be put upon these subjects. It is expected that methods of investigation and habits of thought will have been acquired that will be of great value.

It seems that if students work along together in the Freshman Class, whether from the Preparatory Course here, or from good High Schools, there should be more work done in the Sub-Freshman course. The students should have daily work in English during the two Sub-Freshman years.

SENIOR LOGIC.

In Logic we are handicapped by a text meant for the specialist and not for business or professional man, who wants only to reason carefully and well. The class is small but means business. The library facilities for the study of Logic are nil, hence the greater need of a superior text.

RECOMMENDATIONS.

1. We respectfully recommend that provision be made for more English work in the Sub-Freshman classes, because the work given is not adequate.

2. We recommend either that students, who are deficient in Grammar, be not allowed to enter the First Sub-Freshman Class. or that a course in Grammar be offered.

3. Since almost daily written exercises are necessary for the best work in English, and since much better work could be done in this Department, could we offer a course in Grammar, we recommend that an assistant be secured for the Department, the said assistant to take one or more classes and aid in the manuscript work.

These recommendations are urged in the belief that much better work would result, were they granted.

Respectfully submitted,

B. F. COEN,
Professor of English.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE WORK IN READING.

To The State Board of Agriculture.

Gentlemen—The work in Reading was begun the last of September. It is confined to the Sub-Freshmen who are grouped into two divisions of forty-seven and thirty-seven pupils each. These classes have now diminished to thirty-two and forty-three students.

The aim of the work is to teach students to read aloud intelligently from newspapers and magazines, or understandingly from a text book, if called upon by an instructor in recitation.

In each recitation there is some formal work from a standard text—Interpretative Reading—In addition they are given sight reading from the current press, and practice work in original talks of two minutes each. It takes two recitations to call on each member of a class, and this gives the individual only two or three minutes.

Particular emphasis is placed on the use of the unabridged dictionary. Students are required to use the main body of the work, the various appendices and the supplement. Practice words and phrases are assigned, and the student not only writes out such work in recitation, but must hand in note books at stated intervals. In addition to the dictionary, the use of a few standard reference books, which are to be found in most libraries, is taught.

I think that intelligent reading aloud is rare, and that this accomplishment is useful and practical for the secondary student.

All of which is respectfully submitted,

CHARLOTTE A. BAKER,
Instructor in Reading.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MODERN LANGUAGES.

To the State Board of Agriculture.

Gentlemen—The work in the Modern Languages, including French, German and Spanish, is confined chiefly to the Second Sub-Freshman year, although several students in the higher classes take advantage of the work offered, so that we have, in all, about a hundred in this Department. I am asked, almost every day, why the courses, begun in the Second Sub-Freshman class, are not continued in the college proper. I am certain that we lose students every year, because they cannot get the work in Language which they desire.

I should like to suggest that, in the near future, the scope of this Department be widened and enlarged, that the Language work be carried over into the College course, and that students be given an opportunity to take this work if they so desire. Scientific and Engineering students need this work to enable them to read the technical literature necessary to their advancement and success.

Very respectfully yours,

SARAH I. KETTLE,

Instructor in Modern Languages.

Fort Collins, Colorado, November 12, 1906.

REPORT OF THE WORK IN BOOKKEEPING AND FARM ACCOUNTS.

To The State Board of Agiculture.

Gentlemen—I herewith respectfully submit my report as instructor of Bookkeeping and Farm Accounts.

The class in Bookkeeping is small, owing to the fact that only those students taking a straight course and having the time to devote to this subject are eligible for admission. The present courses of study are so arranged that the student desirous of receiving a knowledge of Accounts finds it, in most cases, impossible to do so. Is not this subject important enough to occupy a place in the curriculum of one or more of our courses? At the present time there are thirteen students in the class, all doing creditable work.

The experience I received with the Short Course students, in Farm Accounts, last year assisted me materially in outlining the work for the class this year. The time being limited for class room work, I was obliged to outline something entirely different to our present system. With "Vye's Farm Accounts" as a text, I have arranged a simple and practical system of accounts, a system adapted for the farmer and stockman and one which requires only the minimum amount of work and at the same time gives the necessary information.

We look for a large attendance at the opening of the Short Course term, December first.

Respectfully submitted,

CHAS. G. DWYRE, JR.,

Instructor in Bookkeeping.

Fort Collins, Colorado, November 13, 1906.

REPORT OF THE LIBRARY DEPARTMENT.

To the State Board of Agriculture.

Gentlemen—The following summary of the annual report concerning the Library is respectfully submitted.

There are a number of items besides the inventory and the statistical matter which would properly come into this report, but the principal part is devoted to an outline of the policy of the library with regard to storage of books and library service.

STORAGE, OR SHELVING AND HOUSING OF BOOKS.

Within five years we have grown in bulk from about 10,000 volumes to about 30,000 volumes, and have moved from the old library rooms into the building lately known as the Commercial Building.

We have added shelving until we have about 4,500 feet, and within five years we shall need more than 7,000 feet. We can add nearly 1,200 feet by building another story to the main stack and 324 feet in the reading room.

Either an addition or box storage will be needed at the end of two years (September, 1908). The expense can be kept below $1,000 for an addition just west of the delivery room and between the two wings.

We have about 6,000 volumes shelved in department libraries in the buildings on the College grounds and that can be increased to 10,000 volumes by building additional shelving, but that does not alter the estimates as given above; that will have to be done in any event, if we continue our present department library policy.

The present library building and present accommodations will shelve about 25,000 volumes only and we have about that number on the shelves.

Documents of the United States government must be shelved or we shall lose our designation. There is an agreement equal to a contract to that effect, and we are observing it to the letter and we could hardly give good service in this library without them.

It is frequently remarked by those who use the library and by our visitors that we need a "new library." We do need a new building, but we need a good book collection first. The *service* which is demanded more and more, year by year, calls for a better collection of literature, maps and reference material than we possess, and this report omits all minor questions in order to give space to the points to be considered in *service*.

SERVICE IN THE LIBRARY OF AN AGRICULTURAL COLLEGE.

An *intensive* collection of books is one which is devoted to a definite field with complete, or nearly complete, material in that field of knowledge. It breeds specialists within the library staff and reinforces all the work of faculty and students, whereas a *general* collection scatters its energy, costs too much money without adequate effect and returns, and duplicates the mediocrity of several neighboring collections.

Nearly all the libraries of Colorado and the West are general collections, and we can easily make this library a *notable* collection by *intensifying.*. It will cost money; as much money as a general collection, but the results are not in the same class. A few libraries in America have caught this idea and are easily leaders for reference work in this classes.

It is cheaper for a scholar to take a journey to the John Crerar library in Chicago for scientific work than to stay at home surrounded by all sorts of general and public libraries; Newberry Library for genealogy; Madison or Topeka for history, etc., etc. (East of Chicago the tale is more complete.)

Our present tendency is toward—

Agriculture.
Engineering (our special field).
Domestic Science.
Public Health.

AGRICULTURE.

The importance of immediate work upon our collection is greater than can be explained without an investigation by an active library committee working through a year with regular meetings. Our collection of documents alone is so weak that we should complete what we can before the material vanishes into the maw of an ever-increasing number of new libraries and libraries who have come to this intensive-collection *policy.*

We have bought about everything in United States Agricultural Department publications for sale in the market, and have some money left which we can not spend by correspondence. Our set is still incomplete and we ought to go out and find where the material is stowed away in duplicate collections, in private collection, and for sale in the market. A personal canvass is all that is left for us, and that must be done before another year if we intend to have a good working set of those very important publications. The same is true of state publications and all other official documents in agriculture.

We have catalogues of about 50,000 printed cards to cover the United States Agricultural Department publications, and it is growing very rapidly.

We can still buy books by correspondence.

ENGINEERING.

Periodicals, transactions of learned and engineering societies, official publications and a mass of monograph literature can be bought by correspondence, but a great deal of that is disappearing and some special effort should be made to assist Professors Lawrence, Carpenter and Bainer in filling lists which their ability would make extremely valuable to this library.

DOMESTIC SCIENCE AND PUBLIC HEALTH.

Official documents, monographs, transactions and occasional publications of great value in scientific and popular research lie all about, and we have a great deal to do before we reach the condition which I have described under the head of Agriculture. We can buy from lists and catalogues for a long time and we can increase our correspondence on all these lines.

GENERAL LITERATURE AND CURRENT INTERESTS.

While we are very well equipped for the work under this head we lack a few books of reference value—dictionaries, concordances, glossaries, lexicons, bibliographies—books which skim the cream and condense information for quick use.

LIBRARY COMMITTEE.

There are two library committees; one of the Board and one of the Faculty, and the relation of these two to the librarian, to library policy, and to each other, has never been clear.

In order to shape a policy for this library there should be a *Library Committee with the Librarian as a member* of that Committee. The Committee should meet several times each year and should become familiar with the whole working of this library. My relations with the Faculty Committee of the Library leads me to think that such a committee would be very helpful. The Faculty are interested in this library and always help whenever there seems to be an occasion, but a committee who would make a business of this library policy for a few years would be of great importance in the future of this library.

To the present incumbent it seems important that the librarian should be a member of the Committee on library.

CATALOGUING.

Our catalogue makes progress more rapidly since we have begun to buy Library of Congress printed cards and, in all, we have about 80,000 cards in catalogue condition, ready for use. 50,000 we received as gift for United States Department of Agriculture publications, and 30,000 are in the new dictionary catalogue. The dictionary catalogue will be increased to about 100,000 as fast as we can arrange them.

This form of service is important, and when combined with the help of intelligent specialists will be worth much more than

the cost. It is now in constant use, although incomplete, and it will soon be the most important help in the library.

A thorough explanation of catalogue service and the preparation of the catalogue is not possible in a report, but a great deal is well understood by every one who has to use a library.

INCREASED USE OF THE LIBRARY.

In spite of the fact that we have large Department Libraries and in the face of our circulation records, which do not appear to change from year to year, we are doing an immense amount of reference work for so small a library in such inadequate floor space and with so few helpers. This little library fairly boils with business during the busy hours of the day, and it is the most gratifying thing to a librarian to see the increase of systematic work and intelligent use of books in the student body. Since the improvements in shelving and lighting in the reading room, there is a growing demand for evening service, and as soon as we can see our way clear to do so, the librarian recommends that the library be open for evening use.

APPRENTICE CLASS IN LIBRARY SCIENCE AND ECONOMY.

We are often asked if we have a training class or a library course, and a brief explanation is given here.

We always have two or three students in library training. We require two years' work and not less than four hours a day. We require in addition to our work a reading knowledge in French, or German, or Spanish. Without this one must take regular College work in one Modern Language. No grade below the College entrance requirements will be considered and higher grades are preferred.

We do not guarantee positions to those who take the work, but we have been fortunate enough to place those who complete the work. We are obliged to limit the number of apprentices and we shall have to omit most of the work in binding until we have more room.

Additional reading, either in College classes or under the librarian is required. Examinations are held as in other work.

HISTORY OF THE LIBRARY.

Information concerning the foundation and history of the library may be found in the annual catalogues of the College. The growth and other statistical matter is given in this and previous annual reports of the librarian.

DONATIONS AND EXCHANGES.

The list of donations is too long for this report, covering several pages.

Our exchanges are extremely valuable and run to a large number of pieces. Our list of addresses for mailing to these exchanges is about 300 in number.

BOOKS IN THE LIBRARY—ANNUAL TABULAR STATEMENT.

Latest accession number		14,300
Missing and withdrawn	1,200	
Experiment station library	1,233	
Blank numbers	777	
		3,200
Number of volumes accessioned in the library		11,100
Number of volumes not accessioned in the library		10,100
Bound volumes in College library		21,200
Pamphlets, duplicates and other unbound matter		18,000
Total of all pieces		39,200

Respectfully submitted,

JOSEPH F. DANIELS,

Librarian.

Fort Collins, Colorado,
November 15, 1906.

REPORT OF THE DEPARTMENT OF PHYSICAL TRAINING.

To the State Board of Agriculture.

Gentlemen—I accepted the position of Physical Director of the Colorado Agricultural College in the latter part of July, 1906. I reported in Fort Collins August 25, 1906, and immediately began active work in the way of becoming acquainted with the general surroundings and planning an outline for my year's work.

I am devoting from seven to eight hours daily to the gymnasium, which is entrusted to my care, and it has been my aim to get the best possible results for the College as well as causing the students to feel satisfied with their work.

During the Fall term I had charge of the football team, and while the work was not entirely satisfactory to me, the season ended without injury to any student thus engaged.

The gymnasium classes, while yet in their inception, show increased improvement in general work. The gymnasium is very well equipped for this class work, and the interest shown by the students pleases me greatly. Owing to this fact it will be a pleasure for me to try to cause each one so interested to be in better physical condition by the end of the year.

The different athletic teams are in my charge and I shall devote such time as is beneficial to the College in general to such sport.

Should any member of the Board or Faculty wish to advise with me in the matter of suggestions for the improvement of this branch of College work, I shall be pleased to have an interview at any time.

Respectfully submitted,

C. J. ROTHGEB,

Physical Director.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE WORK IN DRAWING.

To the State Board of Agriculture.

Gentlemen—I am outlining the drawing for the first Sub-Freshman class this term. I have endeavored to carry it along the lines which will be most helpful to the students later in their class and laboratory work, where some drawing is required.

I have confined the work entirely to pencil drawing. The classes may take up some water color or other medium in the spring term. The work this term has been outline, and light and shade in plant forms, blocks, outdoor sketching on the campus, and some figure sketching. Special attention has been given to the study of the rules and laws of perspective.

There have been seventy enrolled in the two classes together, and the work on a whole has been very satisfactory, much more so, in fact, than I had anticipated.

Yours respectfully,

NELLIE M. KILLGORE,

Instructor in Drawing.

Fort Collins, Colorado, November 30, 1906.

REPORT OF THE DEPARTMENT OF INSTRUMENTAL MUSIC.

To the State Board of Agriculture.

Gentlemen—I commenced work as Head of the Instrumental and Theoretical Department of Music at the Colorado Agricultural College, September, 1906, under a contract by which there shall be no expense to the College. During the first term, I have enrolled sixteen pupils in all; three in Harmony, two in History of Music, and sixteen in Piano. At present I am giving twenty hour lessons a week.

There has been great interest shown by the students in their work, and a continued increase in numbers, which is most hopeful.

Respectfully,

ANNE PARKER MINER,

Instructor in Instrumental and Theoretical Music.

Fort Collins, Colorado, November 30, 1906.

REPORT OF THE DEPARTMENT OF VOCAL MUSIC.

To The State Board of Agriculture:

Gentlemen—Since last September I have had charge of the Vocal Department of the C. A. C., also Band, Orchestra, and Glee Club.

I have a good sized class of vocal students, and more to come in the first of next term. There are twelve voices in the Glee Club, all interested, and in a short time will be in good shape for concert work. The Band consists of twenty pieces and is doing good work. The Orchestra will begin work soon.

Respectfully submitted,

R. C. BEAVER,
Instructor in Vocal Music.

Fort Collins, Colorado, November 15, 1906.

REPORT OF THE DEPARTMENT OF MILITARY SCIENCE.

To The State Board of Agriculture:

Gentlemen—Pursuant to your communication of the 3d instant, I have the honor to render a report covering the period from my joining this Institution to the present.

The undersigned was placed on College duty by Paragraph 10, Special Order No. 39, War Department, dated Washington, D. C., February 14, 1906; joined and assumed command of the Cadet Battalion, and charge of the Department of Military Science and Tactics, March 7, 1906.

The Battalion at that time consisted of a band of 24 musicians and four companies, averaging thirty-eight to the organization, under the command of Major R. A. Maxfield.

The present Battalion is as follows:

Field staff and band	25	
Company "A"	56	
Company "B"	54	
Company "C"	54	
Company "D"	54	
Total		243

During my first inspection of the Battalion I noticed that the uniform was the same as that recently discarded by the Regular Army, and entirely unfit, as well as unbecoming, in every respect. Report to this effect was made to the President of the College, who informed me that such change as I deemed fit to make in this line would meet with his hearty approval; so, as a consequence, a neater and more appropriate blouse was adopted, which has already brought about a great change in the Cadets' appearance, as well as a pride in wearing it. Formerly, and with reason, the blouses of the Cadets were always worn unbuttoned while out of ranks and on the streets, which must have given outsiders a bad impression of the discipline of the College, but now, I am happy to state, this has been overcome and brought about by the recent change in the uniform, which is much more attractive than formerly, their pride having been aroused in a most gratifying manner.

A service chevron has been added lately. Those that have spent three full years in this College, or other like Institutions, are permitted to wear them. This, also, I have reason to believe, will show good results. The band will make a good appearance with its new white belts and breast cords of mixed red and white, to be worn during parades and occasions of ceremony.

The discipline of the College, as I made report to the Military Secretary, U. S. Army, Washington, D. C., last September, is very good. This, considering the fact that the Cadets are only under the immediate command of the instructor about four hours a week, and the rest of the time either in class rooms or quartered out in town, there being no dormitories.

The need of a drill hall is very apparent, for during inclement weather but two companies can drill at a time in the present armory, which is very poorly ventilated and unfit to be used, outside of a place to store rifles and equipment.

I can not renew the recommendation of the former commandant to change the present light Cadet Springfield rifle for the Krag Jorginson rifle, which, I am informed by the Chief of Ordnance, U. S. Army, has not been lightened for Cadet organization. A rifle any heavier than the present one could not be well handled by certain of the Cadets not up to the physical standard of the others in the companies.

It is to be regretted that no target range is within easy reach of the College, but since so small an allowance of ammunition is allotted, I do not believe good results could be obtained; it takes weeks of very careful training in pointing, sighting and aiming drill before one is qualified to go to the target range. In the meantime the drilling of the companies and battalion is close and extended order ceases.

Lectures and instruction are to be given the Cadets in the following Military subjects: Field service regulations, Army regulations, Hygiene, First aid to the wounded, Firing regulations, and Guard Duty. This is outside of the weekly three-hour practical instruction.

A system of marking should be adopted by the Faculty whereby the Military Professor can tighten up the strings of discipline where needed; standing in the Military Department should count equally with other departments, and those not qualifying themselves should be expelled from the Institution no matter what their standing be.

The Company drill has greatly improved in the last few months.

The interest taken in the Military Department by the President of the College is most gratifying, and I wish also to record my appreciation of the courtesy and prompt support given me as Commandment.

Respectfully submitted,

THOMAS M. ANDERSON, JR.,
Captain 7th U. S. Infantry,
Professor Military Science and Tactics,
Commanding Battalion.

Fort Collins, Colo., November 15, 1906.

APPENDIX

AUDIT OF

State Agricultural College

FROM

DECEMBER 1, 1892, TO NOVEMBER 30, 1903

By Harry E. Mulnix

FROM

DECEMBER 1, 1903, TO NOVEMBER 30, 1906

By Continental Trust Company,

By E. F. Arthur, Auditor.

To the Honorable State Board of Agriculture.

Gentlemen—I have the honor herewith to hand you my report of the business transactions of the Agricultural College and Experiment Station for the period commencing December 1, 1892, and ending November 30, 1903.

I am pleased to say that I find the accounts as kept by your Secretary, Mr. A. M. Hawley, to be in most excellent shape. I believe, however, that his work, which in my opinion is heavier than it should be, can be lessened, if the funds which can be legally drawn from the State Treasurer in a "lump" sum, and paid out locally, are handled in this manner. At present, with the exception of a very few bills, his office is required to make out both vouchers and bills in duplicate. This system, while it is necessary in the present manner of disbursing the college funds, could be safely changed if the accounts were paid at the College in cash, in which case but one voucher and one bill would be necessary. Then, too, in the matter of salaries and student labor accounts, permit me to offer the suggestion that the Secretary make up a pay roll in books prepared for the purpose, and instead of the person being compelled to receipt two vouchers and two bills he would only be required to sign the book when paid. This, I believe, would be a sufficient record for the Institution and would reduce the work of the Executive Committee, the Secretary, and all others who have to handle the accounts of the Agricultural College.

I might add that the disbursements of the Agricultural College funds require more work in the Auditor of State and the State Treasurer's Offices than do all the other state educational institutions combined.

I have made some suggestions to Secretary Hawley with reference to the accounts which my familiarity with the offices of the Auditor and the Treasurer of State leads me to believe that if followed may be of much benefit.

Respectfully submitted,

H. E. MULNIX,

Examiner.

Fort Collins, Colorado, June 1, 1904.

RECEIPTS AND DISBURSEMENTS.

Experiment Station Fund.

Local Treasurer.

RECEIPTS.

1893—December 1 to June 30	$ 8,713.73	
1893-4	19,675.26	
1894-5	17,287.55	
1895-6	15,000.00	
1896-7	15,065.86	
1897-8	15,000.00	
1898-9	15,000.00	
1899-00	15,000.00	
1900-01	15,000.00	
1901-2	15,000.00	
1902-3	15,000.00	
1903—November 30	7,500.00	
		$173,242.40

DISBURSEMENTS.

Overdraft, November 30, 1892	$ 462.82	
Printing Annual Report	1,046.44	
Salary Account	104,661.27	
Stationery, etc.	497.28	
Printing Bulletins	10,886.08	
Building Account	1,697.25	
Meteorology and Irrigation	5,537.97	
Library	171.08	
Divide Station	1,881.94	
Cheyenne Station	6,582.76	
San Luis Valley Station	3,878.63	
San Luis Valley Station Survey	431.67	
Seepage Survey	856.03	
Contingent Expense	30.00	
Feeding Experiment	3,392.62	
Director's Office	2,239.05	
Chemical Section	3,708.18	
Entomological Section	1,947.52	
Arkansas Valley Station	17,110.80	
Executive Committee	409.85	
Association of Agricultural Colleges	70.00	
Agricultural Section	2,002.43	
Horticultural Section	2,062.21	
Traveling	27.50	
Unexpended balance, November 30, 1903	1,651.02	
		$173,242.40

EXPERIMENT STATION.

Special Fund.

Local Treasurer.

RECEIPTS.

1897 and 1898	$ 1,909.11	
1898 and 1899	2,649.40	
1899 and 1900	1,364.78	
1900 and 1901	1,711.85	
1901 and 1902	2,727.69	
1902 and 1903	623.20	
		$ 10,986.03

DISBURSEMENTS.

Agricultural Section	$ 163.81	
Arkansas Valley Station	2,195.65	
Printing Bulletins	1,240.45	
Chemical Section	447.25	
Entomological Section	278.09	
Feeding Experiment	358.65	
Horticultural Section	410.62	
Meteorology and Irrigation	911.56	
Rainbelt Station	741.75	
Salary Account	2,153.29	
San Luis Valley Station	382.70	
Executive Committee Expense	444.35	
Divide Station	21.80	
Stationery Account	110.50	
Director's Office	1,085.57	
Library Account	39.99	
		$ 10,986.03

EXPERIMENT STATION.

Special Fund.

State Treasurer.

RECEIPTS.

1895.		
July	$ 262.62	
September	201.88	
October	159.48	
November	243.85	
December	10.00	
1896.		
March	187.40	
April	835.25	
May	773.66	
June	278.57	
September	60.41	
November	149.96	
December	47.00	
February	162.13	
March	65.60	
		$ 3,437.81

DISBURSEMENTS.

Executive Committee	$ 454.40	
Traveling Expense	24.15	
Arkansas Valley Station	474.56	
Feeding Experiment	123.00	
Salary Account	1,468.28	
Printing Bulletins	555.27	
Printing Annual Reports	100.00	
San Luis Valley Station	75.00	
Chemical Section	30.60	
Irrigation Section	98.50	
Horticultural Section	5.25	
Rainbelt Station	28.80	
		$ 3,437.81

SUMMARY EXPERIMENT STATION AND EXPERIMENT STATION SPECIAL ACCOUNTS.

November 30, 1892, to November 30, 1903.

RECEIPTS.

Experiment Station (Local Treasurer)	$173,242.40	
Experiment Station (State Treasurer)	3,437.81	
Special Fund (Local Treasurer)	10,986.03	
		$187,666.24

DISBURSEMENTS.

Overdraft, November 30, 1892	$ 482.82	
Printing Annual Report	1,146.44	
Salary Account	108,282.84	
Stationery, etc.	607.78	
Printing Bulletins	12,681.80	
Building Account	1,697.25	
Meteorology and Irrigation	6,449.53	
Library	211.07	
Divide Station	1,932.54	
Cheyenne Station	7,324.51	
San Luis Valley Station	3,953.63	
San Luis Valley Survey	431.67	
Seepage Survey	856.03	
Contingent Expense	30.00	
Feeding Experiment	3,874.27	
Director's Office	3,324.62	
Chemical Section	4,186.03	
Entomological Section	2,225.61	
Arkansas Valley Station	19,781.01	
Executive Committee	1,308.60	
Association of Agricultural Colleges	70.00	
Agricultural Section	2,166.24	
Horticultural Section	2,478.08	
Traveling Expense	51.65	
San Luis Valley Station	382.70	
Irrigation Section	98.50	
Unexpended balance, November 30, 1903	1,651.02	
		$187,666.24

AGRICULTURAL COLLEGE AND MECHANIC ARTS' FUND.

RECEIPTS.

Balance in Treasury November 30, 1892	$ 8,209.44	
1893 and 1894	19,000.00	
1894 and 1895	20,203.00	
1895 and 1896	21,000.00	
1896 and 1897	22,000.00	
1897 and 1898	23,000.00	
1898 and 1899	24,000.00	
1899 and 1900	25,000.00	
1900 and 1901	25,000.00	
1901 and 1902	25,000.00	
1902 and 1903	25,000.00	
1903 and 1904	25,000.00	
		$262,412.44

DISBURSEMENTS.

Salary Account	$244,174.46	
Mechanical Department	2,641.14	
Horticultural Department	657.88	
Chemical Department	4,565.78	
Physics and Engineering	1,800.24	
Mathematical Department	32.60	
Zoology and Entomology	619.98	
Library	22.57	
Farm Department	95.40	
History and Literature	93.50	
Unexpended balance, November 30, 1903	7,708.89	
		$262,412.44

RECEIPTS AND DISBURSEMENTS OF AGRICULTURAL COLLEGE TAX FUND.

RECEIPTS

Balance in Treasury November 30, 1892	$ 11.61	
1893 and 1894	34,830.03	
1894	35,352.24	
1895	33,299.51	
1896	31,711.63	
1897	38,072.61	
1898	38,786.56	
1899	36,616.02	
1900	38,504.97	
1901	41,010.48	
1902	60,795.37	
1903	72,858.92	
Overdraft	900.23	
		$462,750.18

DISBURSEMENTS.

Overdraft, November 30, 1892	$ 4,378.80	
1893	26,687.67	
1894	34,876.59	
1895	38,098.16	
1896	32,600.67	
1897	33,777.25	
1898	40,907.68	
1899	32,201.65	
1900	32,945.99	
1901	51,066.38	
1902	59,592.89	
1903	75,410.21	
Transfers and refunds	206.24	
		$462,750.18

RECEIPTS AND DISBURSEMENTS OF THE LAND INCOME FUND.

RECEIPTS.

Balance in Treasury December 1, 1892	$ 5,282.81	
1893-94	9,561.09	
1895-96	9,313.04	
1897-98	13,890.14	
1899-00	16,624.03	
1901-02	20,256.26	
1903	8,369.57	
		$ 83,296.94

DISBURSEMENTS.

1893	$ 10,305.38	
1894	4,286.63	
1895	3,186.16	
1896	5,416.63	
1897	5,893.98	
1898	8,853,83	
1899	....	
1900	10,913.09	
1901	10,851.76	
1902	13,124.26	
1903	9,968.12	
Reimbursement	361.56	
Balance, December 1, 1903	135.54	
		$ 83,296.94

RECEIPTS AND DISBURSEMENTS OF SPECIAL FUND.

RECEIPTS.

Balance in Treasury December 1, 1892	$ 269.21	
1893-94	5,910.38	
1895-96	5,389.24	
1897-98	3,782.51	
1899-00	5,322.26	
1901-02	11,672.73	
1903	15,141.86	
		$ 47,488.19

DISBURSEMENTS.

1893	$ 1,377.75	
1894	4,417.44	
1895	3,462.15	
1896	1,957.85	
1897	3,786.18	
1898	146.09	
1899	5,245.21	
1901	5,779.80	
1902	5,941.73	
1903	15,175.82	
Transfers	161.65	
Balance December 1, 1903	36.52	
		$ 47,488.19

RECEIPTS AND DISBURSEMENTS OF THE ANNIE JONES LIBRARY FUND.

RECEIPTS.

1895-96	$ 2,836.05	
1897-98	45.00	
1899-00	158.90	
1901-02	854.07	
1903	204.45	
		$ 4,098.47

DISBURSEMENTS.

1896	$ 2,692.90	
1897	147.35	
1898	31.00	
1899	18.00	
1900	18.00	
1901	40.72	
1902	343.75	
1903	200.95	
Balance	605.80	
		$ 4,098.47

STATEMENT OF DISBURSEMENTS OF SPECIAL APPROPRIATIONS MADE BY THE COLORADO GENERAL ASSEMBLY.

1893	By the Ninth General Assembly	$ 6,500.00	
1895	By the Tenth General Assembly	10,000.00	
1901	By the Thirteenth General Assembly	8,000.00	
			$ 24,500.00

DISBURSEMENTS.

	1893.			
July	Sewer Account	$ 1,248.27		
Aug.	Sewer Account	1,416.60		
Sept.	Sewer Account	2,900.53		
Oct.	Sewer Account	934.60		
			$ 6,500.00	
	1896.			
Dec.	General Improvement Account	$ 100.00		
Jan.	General Improvement Account	4.40		
Feb.	General Improvement Account	461.72		
Mar.	General Improvement Account	581.80		
Apr.	General Improvement Account	458.98		
May	General Improvement Account	1,203.20		
June	General Improvement Account	642.70		
July	General Improvement Account	1,327.75		
Aug.	General Improvement Account	872.48		
Sept.	General Improvement Account	2,377.73		
Oct.	General Improvement Account	1,249.25		
Nov.	General Improvement Account	718.99		
	1897.			
Sept.	General Improvement Account	1.00		
			$ 10,000.00	
	1902.			
Apr.	Student Labor Account (special)	$ 2,000.00		
Aug.	Improvement Account (special)	2,387.32		
Sept.	Improvement Account (special)	1,740.40		
Oct.	Improvement Account (special)	529.87		
Nov.	Improvement Account (special)	1,342.41		
			$ 8,000.00	
				$ 24,500.00

STATEMENT SHOWING THE RECEIPTS AND FOR WHAT DEPARTMENTS AND ACCOUNTS THE REVENUES OF THE TAX, INCOME, SPECIAL, ANNIE JONES LIBRARY AND SPECIAL APPROPRIATION FUNDS WERE DISBURSED, AND THE AMOUNT CHARGED TO EACH.

RECEIPTS

Tax Fund	$461,849.95	
Special Appropriation	24,500.00	
Special Fund	47,488.19	
Land Income Fund	83,296.94	
Annie Jones Library	4,098.47	
Overdraft	122.37	
		$621,355.92

DISBURSEMENTS

Overdraft, November 30, 1892	$ 4,378.80
Electrical Engineering	447.64
Constitution and History	15.69
Seed Distribution	45.70
Zoology and Entomology	3,963.89
Domestic Economy	3,224.76
Commercial Department	4,053.72
Library Account	7,802.70
Horticultural Department	21,851.21
Farm Department	50,539.81
History and Literature	286.37
President's Office	3,646.14
Student Labor Account	22,796.66
Building Account	225.00
Fair Exhibit	251.19
Insurance	9,517.94
State Board of Agriculture	26,754.23
Dairy Account	882.41
Chemical Department	6,112.70
English and Stenography	461.34
Mechanical Department	21,740.29
Mathematical Department	591.82
Furniture Account	4,835.43

DISBURSEMENTS—Continued

Physics and Engineering	7,925.88
Remodeling Dormitory	2,075.51
Current Expense	39,898.34
Light and Fuel	18,629.18
Veterinary Science	1,358.11
Text-Book Account	25,261.66
General Repairs	14,313.21
Salaries	132,546.56
Secretary's Office	2,280.45
Military Department	1,040.19
Improvement on Grounds	378.27
Permanent Improvements	74,984.31
Advertising	8,670.98
Hose House	3.84
Agricultural Hall	945.00
Farm House	670.35
Mechanic Shop	182.75
Farmers' Institutes	1,668.12
Annie Jones Library Special	533.95
Freight and Express	8,007.16
Annual Catalogue	4,377.85
Membership A. A. A. C.	70.00
Farm Siphon	5.00
World's Fair Exhibit	857.11
Water Supply	322.25
Sewers	7,118.88
Mechanical Building Heating	1,211.84
Drainage Account	233.40
College Stand Pipes	304.71
Engineering Building	42.00
Mechanical Building Closets	418.91
Irrigation Pipe Line	2,896.22
Extension Water Mains	759.43
Secretary's Report	43.75
Horticultural Building	14,715.41
Compiling Laws	132.00
Reimbursing United States	200.00
Farm Root Cellar	148.00
Flag and Staff	25.00
Course in Agriculture	187.80
Feeding	621.29

DISBURSEMENTS—Continued

Domestic Economy Building Repairs	359.01	
Horticultural Building Furniture	499.75	
Greenhouse	3,106.38	
Flagging	240.92	
Chemical Building	29,250.62	
Plumbing	225.26	
Annie Jones Library	3,492.67	
Advertising Pamphlet	223.45	
Mechanical Engineering Building	4,727.80	
Repairs on Barn	4.50	
Student Labor Special	2,000.00	
Improvement Special	6,000.00	
Refunds and Transfers	729.45	
		$621,355.92

AUDIT STATE AGRICULTURAL COLLEGE.

December 1, 1903, to November 30, 1906.

Hon. P. F. Sharpe, President State Board of Agriculture, Fort Collins, Colorado.

Dear Sir—Pursuant to the instructions of your executive committee, we have made an audit of the books and accounts of the State Agricultural College from December 1, 1903, to November 30, 1906, and herewith submit our findings.

SECRETARY'S CASH.

All collections have been properly accounted for and paid over to the State and local treasurers.

DISBURSEMENTS.

All disbursements are evidenced by duly authenticated bills, and all vouchers are properly approved by the finance committee.

LOCAL TREASURER.

We verified the balances shown as in hands of local treasurer, and find them to be correct.

STATEMENTS.

The following statements exhibit the transactions of the past three years:

SECRETARY'S CASH ACCOUNT.

RECEIPTS.

Balance Library Fund, December 1, 1903	$ 1,056.81	
Agricultural Department, sales	8.723.40	
Agricultural Station, sales	201.60	
Agronomy Department, sales	28.57	
Agronomy Section, sales	338.94	
Animal Husbandry Department. sales	4,805.64	
Appropriation Fund transfers	3,328.41	
Arkansas Valley Sub-station sales	723.13	
Animal Investigation	142.00	
Commercial Department, sales	30.00	
Chemical Department, sales	107.50	
Chemical Section, sales	271.75	
Civil and Irrigation Engineering Department, sales	270.00	
Domestic Science Department, sales	19.25	
Directors' Office, sales	893.02	
Entomological Department, sales	10.00	
Engineering Department, sales	350.00	
Entrance Fees	1,502.00	
Freight Refunded	445.44	
Farm Division sales	32.50	
Gymnasium Fund	253.00	
Girls' Dormitory	345.61	
Horticultural Department, sales	163.50	
Horticultural Section, sales	25.74	
History and Literature Department, sales	12.60	
Insurance Refunded	10.00	
Irrigation and Engineering Section, sales	5.00	
Library Department, sales	74.95	
Library Fund Collections (Annie Jones)	407.80	
Mechanical Department, sales	43.83	
Miscellaneous, sales	150.95	
Music Fees	295.50	
Physics Department, sales	9.85	
Registration Fees	36.00	
San Luis Valley Sub-station, sales	1,672.14	
Text Book Department, sales	8,222.17	
Western Slope Fruit Investigation	1,125.00	
Western Slope Fruit Investigation, Transfer	1,303.11	
		$ 37,436.71

DISBURSEMENTS.

Paid State Treasurer, Special Fund, 1904	$ 8,250.03	
Paid State Treasurer, Special Fund, 1905	7,589.37	
Paid State Treasurer, Special Fund, 1906	12,590.03	
Paid State Treasurer, Library Fund	1,464.61	
Paid Local Treasurer, Special Fund, 1904	1,555.34	
Paid Local Treasurer, Special Fund, 1905	231.10	
Paid Local Treasurer, Special Fund, 1906	5,756.23	
		$ 37,436.71

RECEIPTS AND DISBURSEMENTS.

	Balance Dec. 1,	RECEIPTS.			DISBURSEMENTS.			Balance Nov. 30,
	1903.	1904.	1905.	1906.	1904.	1905.	1906.	1906.
Agricultural College, Tax Fund ....$	900.23*	$ 64,036.53	$ 69,067.32	$ 69,755.00	$ 61,429.70	$ 66,812.37	$ 75,711.10	$ 1,994.55*
Agricultural College, Land Income Fund........	135.54	6,161.61	31,107.00	18,354.31	8,958.66	27,088.27	19,353.48	358.05
Agricultural College, Library......................	605.80	1,464.61	....	....	895.10	....	1,175.31	....
Agricultural College, Special	36.52	8,257.53	7,589.37	12,590.03	8,294.05	6,156.76	10,811.84	3,210.80
Agricultural College, Mechanical Arts (U. S.)...	7,708.89	25,000.00	25,000.00	25,000.00	26,016.42	23,275.68	24,562.23	8,854.56
Appropriation, Agricultural Instruction..........	....	....	8,000.00	....	....	4,013.23	3,986.77	....
Appropriation, Farmers' Institutes...............	....	....	8,000.00	....	....	897.34	7,102.66	....
Appropriation, Animal Industry	....	....	10,000.00	....	....	639.24	9,360.76	....
Appropriation, Plant Industry	....	....	3,000.00	....	....	941.71	2,058.29	....
Appropriation, Root Crops	....	....	1,000.00	....	....	....	1,000.00	....
Experiment Station (Hatch) Fund	1,651.02	15,000.00	15,000.00	15,000.00	14,854.46	15,242.16	16,840.87	286.47*
Experiment Station (Adams) Fund	....	....	....	6,750.00	....	....	6,294.74	455.26
Experiment Station, Special Fund	15.50	1,555.34	231.10	5,756.23	834.19	281.70	5,376.44	1,065.84
Totals ....$	9,253.04	$121,475.62	$177,994.79	$153,205.57	$121,282.58	$145,348.46	$183,634.49	$ 11.663.49

*Overdraft.

DISBURSEMENTS, COLLEGE FUNDS.

	1904	1905	1906
Agricultural Department	$ 10,789.00	$ 14,459.10	....
Agronomy Division	....	10.80	$ 780.72
Animal Husbandry Division	....	....	5,414.25
Farm Division	....	....	5,842.15
Farm Mechanics Division	....	....	236.58
General Agriculture Division	....	....	4,732.20
Advertising	1,490.49	2,149.17	2,039.28
Bulletins, Catalogues and Reports	417.68	881.40	1,114.30
Association American Agricultural Colleges and Experiment Stations	15.00	15.00	15.00
Chemical Department	1,724.16	1,184.94	759.75
Commercial Department	384.85	95.82	16.65
Constitutional History and Irrigation Law Department	20.50	10.45	53.85
Current Expense	2,464.86	2,112.22	804.10
Civil and Irrigation Engineering Department	752.50	1,143.81	2,019.17
Domestic Science Department	430.25	603.37	551.06
English and Sociology Department	16.70	43.87	9.15
Electrical Engineering Department	595.99	1,282.63	....
Electrical Supplies	....	407.98	162.90
Furniture	1,513.10	1,734.50	....
Freight and Express	1,343.96	2,436.29	1,557.01
Fuel and Lights	3,990.44	3,756.04	4,785.86
Farmers' Institute Division	563.55	1,485.94	5,003.19
Firemen and Janitors	....	....	3,282,26
General Repairs	2,202.77	3,684.72	2,043.04
Girls' Dormitory	....	1,272.45	785.41
Horticultural Department	2,872.43	3,780.99	3,465.00
History and Literature Department	47.25	58.47	27.50
Insurance	311.05	1,160.10	993.75
Library	1,856.56	1,761.15	2,695.19
Mechanical Department	2,700.23	4,440.34	2,368.39
Mathematical Department	16.00	13.70	8.60
Military Department	155.14	229.46	74.22
Music Department	....	....	118.84
Modern Languages Department	....	....	13.45
President's Office	250.83	562.43	1,442.67
Physical Training Department	....	....	17.30
Permanent Improvements	9,967.23	12,496.12	14,060.31
Salary	50,191.96	53,775.27	61,807.02
Secretary's Office	255.44	816.20	985.82

DISBURSEMENTS, COLLEGE FUNDS—Continued.

State Board of Agriculture	1,458.85	1,742.55	1,291.40
Student Labor	3,862.19	3,988.69	3,655.80
Text-Book Department	2,632.09	3,111.50	3,305.01
Veterinary Science Department	106.85	137.07	352.30
Zoology and Entomological Department	194.03	1,399.11	222.66
Transfers to other funds	....	....	3,790.28
Totals	$105,593.93	$128,243.65	$142,703.39

DISBURSEMENTS, EXPERIMENT STATION FUNDS.

	1904	1905	1906
Agricultural Section	$1,335.48	$ 869.56	$ 56.27
Association American Agricultural Colleges and Experimental Stations	15.00	....	....
Arkansas Valley Sub-station	49.36	45.65	54.12
Animal Investigation Section	....	144.83	2,024.11
Agronomy Section	....	310.35	2,483.55
Bulletins and Reports	518.20	2,521.98	5,457.19
Buildings	....	141.40	5,236.68
Chemical Section	366.51	31.75	1,345.47
Director and General	536.56	530.72	1,716.58
Entomological Section	294.71	327.02	1,053.05
Horticultural Section	284.68	390.48	1,570.48
Insurance	....	6.00	33.00
Library	21.42	59.42	1,912.63
Meteorological and Irrigation Section	893.77	252.26	2,347.39
Plains Sub-station	74.00	....	....
Salary	11,292.96	10,681.10	11,136.07
San Luis Valley Sub-station	6.00	....	....
Veterinary Section	....	234.60	951.83
Western Slope Fruit Investigation	....	....	2,428.11
Transfers to other funds	....	557.69	1,121.57
Totals	$15,688.65	$17,104.81	$40,931.10

CERTIFICATE.

We have made an audit of the books of the State Agricultural College from December 1, 1903, to November 30, 1906, inclusive; and in accordance therewith we certify that the foregoing statements correctly represent the transactions for the period named.

THE CONTINENTAL TRUST COMPANY,
E. F. ARTHUR,
Auditor.

(SEAL.)
Dated December 8, 1906.

Note—Mr. Arthur also says, "The system in use for the payment of accounts through the State Treasurer is cumbersome and antiquated. Every invoice is duplicated for attachment to the voucher drawn on the State Auditor. If all funds can be drawn from the State Treasurer in bulk and placed in the hands of the local treasurer, this duplication can be avoided and accounts paid by warrant on the local treasurer, each warrant specifying the fund against which it is drawn."

THE STATE AGRICULTURAL COLLEGE
OF COLORADO

NINETEENTH ANNUAL REPORT

OF

THE AGRICULTURAL EXPERIMENT STATION

FOR

1906

LETTER OF TRANSMITTAL.

To His Excellency,
HENRY A. BUCHTEL,
Governor of Colorado.

In accordance with the requirements of an act of Congress providing for the establishment of agricultural experiment stations, I have the honor to present herewith the report of the Colorado Experiment Station, it being the nineteenth annual report. The report of the activities of the Station is for the whole year, while the fiscal report ends with June 30, in conformity with the fiscal year of the United States.

The report and the accompanying documents give an indication of the activity of the Station. The publication of the experiments is made in separate form, as bulletins, which are widely distributed among the agricultural population of the State.

Respectfully submitted,

L. G. CARPENTER,
Director.

The Agricultural Experiment Station,
State Agricultural College,
Fort Collins, Colorado,
January, 1907.

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

THE STATE BOARD OF ARGRICULTURE.

	Term Expires
HON. P. F. SHARP, *President*, Denver	1907
HON. HARLAN THOMAS, Denver	1907
HON. JAMES L. CHATFIELD, Gypsum	1909
HON. B. U. DYE, Rocky Ford	1909
HON. B. F. ROCKAFELLOW, Canon City	1911
HON. EUGENE H. GRUBB, Carbondale	1911
HON. A. A. EDWARDS, Fort Collins	1913
HON. R. W. CORWIN, Pueblo	1913

GOVERNOR JESSE F. McDONALD,
PRESIDENT BARTON O. AYLESWORTH, } *ex-officio.*

EXECUTIVE COMMITTEE IN CHARGE.

P. F. SHARP, CHAIRMAN. B. F. ROCKAFELLOW.
A. A. EDWARDS.

STATION STAFF.

L. G. CARPENTER, M. S., *Director*	Irrigation Engineer
C. P. GILLETTE, M. S	Entomologist
W. P. HEADDEN, A. M., PH. D	Chemist
W. PADDOCK, M. S	Horticulturist
W. L. CARLYLE, M. S	Agriculturist
G. H. GLOVER, B. S., D. V. M	Veterinarian
W. H. OLIN, M. S	Agronomist
R. E. TRIMBLE, B. S	Assistant Irrigation Engineer
F. C. ALFORD, M. S	Assistant Chemist
EARL DOUGLASS, M. S	Assistant Chemist
A. H. DANIELSON, B. S.*	Assistant Agriculturist
S. ARTHUR JOHNSON, M. S	Assistant Entomologist
B. O. LONGYEAR, B. S	Assistant Horticulturist
J. A. McLEAN, A. B., B. S. A	Animal Husbandman
E. B. HOUSE, M. S	Assistant Irrigation Engineer
F. KNORR**	Assistant Agronomist
P. K. BLINN, B. S.	Field Agent, Arkansas Valley, Rocky Ford
E. R. BENNETT, B. S	Potato Investigations

WESTERN SLOPE FRUIT INVESTIGATIONS, GRAND JUNCTION.

O. B. WHIPPLE, B. S	Field Horticulturist
E. P. TAYLOR, B. S	Field Entomologist

OFFICERS.

L. G. CARPENTER, M. S	DIRECTOR
A. M. HAWLEY	SECRETARY
MARGARET MURRAY	CLERK

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*Resigned December 1, 1905.
**Appointed December 1, 1905.

REPORT OF THE DIRECTOR.

ORIGIN AND ORGANIZATION OF THE STATION.

The Experiment Station of Colorado was organized in February, 1888, in accordance with the Hatch act of Congress, passed in 1887, and made effective in 1888. The organization is under a Director, with the subdivisions of the Station called sections. The idea in this organization was that the Station as a whole had the rank of a department. The Executive Committee has more direct charge of the Experiment Station. The rules relating to organization were adopted by the Board some years since, adopting the suggestion of the Director of Experiment Stations of the U. S. Department of Agriculture. The Board has also recognized that the Experiment Station is the experimental and investigational side of the College, and has provided by resolution that all experimental work shall be considered as a part of the Experiment Station, and, therefore, under its direction. Under the State law experimental work is contemplated as a duty of the State Board of Agriculture, and it seems proper for some of the funds to be used for such purposes if the Board deems it advisable. In that respect our State law is broader than the laws in most states.

The appropriation from the Hatch fund is $15,000 per annum. This fund is surrounded by certain limitations, but is much broader than the provisions relating to the Adams fund. Some supervision rests in the Secretary of Agriculture.

At one time a large part of this fund was diverted to substations. The United States decided that this was not a proper charge on the Hatch fund, and that such use must be discontinued. The older members of the Board will remember the period of several years' effort to withdraw from the substations, and the local influence, without entanglements and without getting into difficulties.

The Adams bill has been passed through the efforts of the Agricultural Colleges and Experiment Stations the past winter. This fund is much more restricted in its provisions. Five thousand dollars was available the first fiscal year, $7,000 the second, and so on, increasing until it reaches the full amount of $15,000. In the case of this fund it can not be used for many purposes for which the Hatch fund is available. It can not be used for printing, for administration, postage nor many of the other necessary functions of the Station. It is available only for original scientific research and experiment. This fund is also more directly under the control of the Secretary of Agriculture.

During the past year some funds have been available from an appropriation by the State. This appropriation has been for special purposes. Also, some revenue has been received from the Fruit Growers of the Western Slope for investigations, which have been supplemented by the Board.

FUNCTION AND OBJECTS OF THE STATION.

The passage of the Adams bill, and the questions and discussions which have arisen from it, have caused a very general consideration of the scope and function of the Experiment Stations. Serious thought has been given not only here, but in all the other Stations in the Union, and has been the subject of discussion at the meeting of the Experiment Stations, at the Society for the Promotion of Agricultural Science and related organizations. Both the Hatch and Adams acts give a different interpretation.

In the eighteen years since the organization of the Experiment Stations under the Hatch act, the Stations have been reaching a clearer understanding of their functions. They have gained a much larger hold on the public mind, and in this very fact lies also a danger to the most important work of the Experiment Stations. With the development of their work there has been a constant tendency for greater demands to be made upon the Stations, often a proper one, especially when the demand is accompanied by funds from the State appropriation to meet the demand. In such cases, the conditions surrounding the work and the duties of the Station may be whatever the State may deem desirable to assign, so far as the State funds will permit. Therefore the lines of work in such states supported by state appropriations can not be taken as a guide for those lines which depend wholly upon United States funds.

The Hatch fund is available for research and experiments and for verification of experiments, and for printing and distributing results.

The Adams fund can be used only "for paying the necessary expenses of conducting original research and experiments." This limitation in the scope of the act was an intentional one on the part of Mr. Adams, and means much in the interpretation of the act. It had been felt that in many cases the Hatch fund had not been used properly, and that the temptation was to use it for doing work that was popular and not scientific, and that work was often undertaken that should more properly be undertaken by the State.

The act was intended by the author to encourage, if not to force, the various states to supplement the fund by appropriations or other funds. The Adams act makes no provisions for heating, lighting, buildings, janitor service, publications, correspondence, stenographers and many other indirect but necessary expenses. A result of the investigations will be an increase in the number of publications, and probably in the number of copies which need to be printed. The work under the Adams fund was

not intended to include the application, but to be the research which would permit the applications to be made at other expenses. Hence, in order to make use of the funds provided by the Adams act, considerable additional money is needed.

The first effect of the Adams act will not be, therefore, to relieve the financial situation of the Station. But as it makes the obligation correspondingly greater, it will be still more difficult to make ends meet in the future unless there can be other support.

There will undoubtedly be disappointment with the first results of the act, because such researches as are contemplated by the act can not reach conclusions short of several years, and, therefore, for the first few years there may be a feeling that the apparent results are not commensurate with the cost. There is however a growing realization of the fact that the best results come from this thorough work. The Department excludes such tests as variety tests, market tests, and tests that do not tend to answer definitely the question "why," or to determine the reasons.

There are so many lines of usefulness for a scientific staff and so many opportunities, that there has been an increasing call for the Stations to do work of a secondary grade, like testing plants, determining the merits of different varieties, testing seed, testing the merits of the different combinations of food, and in short to do many things which do not require any particular scientific knowledge, but only opportunity, and possibly some funds. Some phases of this work are often of extreme economic importance to a community or to the State. The improvement of wheat, the distribution of an improved variety of wheat, the development of an improved variety of potatoes, may be a matter of very great importance. It is the kind of work which naturally clusters around an Experiment Station, and in the past the various states have done a great deal of this kind of work. Such work has been supported mostly, if not entirely, from other funds, but as that fact is not made clear in the publications of the Stations, it gives a wrong idea of what the Stations could do from government funds. Such work is extremely valuable to supplement the more scientific work of the Stations. It is a work whose financial benefit is more immediately seen. It was, therefore, left without aid by Mr. Adams, with the feeling that its financial importance would command support, and this should be from the states, or from other sources.

For these purposes, and for the general purpose of utilizing the Adams fund to the best advantage, some support is needed from the State, and should increase more as the Adams fund becomes larger.

The Legislature two years ago made an appropriation to the State Board of Agriculture for the Experiment Station, and a continuation is needed for the present biennial period. The amount appropriated in 1905 in S. B. No. 172, approved April 6th,

was $14,000 for the biennial period; $10,000 for the lines of animal industry; $3,000 for the lines of plant industry, and $1,000 for potatoes and other root crops.

This appropriation has proven to be of such value, and has been so useful in many parts of the State, that a continuation and extension of the purposes for which these funds were available is needed.

While there is increased recognition of this application of scientific research, it can not be too frequently impressed that these applications can not be made unless the research has previously been made. These applications must depend upon sound research, and it is this work which is the highest function of the Experiment Station, and is the work which is intended to be fostered by the Adams act. Research in the broader sense attempts to answer the question "why." It requires the highest kind of intelligent effort, and should be classed with the highest kind of creative work. The investigator requires peculiar conditions. He should be separated from disturbing influence and from such routine work as saps his energy and vitality and which could be done by cheaper help.

The value of these conditions as provided by Mr. Adams will be increasingly evident as the years go by.

THE FRUIT INVESTIGATIONS.

The fruit growers of the Western Slope made special request for help in the problems which were troubling them, and offered to raise considerable money if the State Board of Agriculture would supply men to aid them, under the direction of the Experiment Station. The Station could not use its funds. Realizing the value of such work, the State Board of Agriculture made special provision, and with the aid furnished by the fruit growers of Mesa county, they carried on investigations on the Western Slope during the past year. The general investigation included two men, one Field Horticulturist and one Field Entomologist, working under the direction of the Horticulturist and Entomologist of the Experiment Station. The investigation was to include the study of the orchard conditions of Mesa county, especially of the injurious insects, the means of combatting them, and the means of improving conditions. Mr. O. B. Whipple, who was Assistant Horticulturalist, was detailed for the work at Grand Junction, under the direction of Prof. Paddock, and Mr. E. P. Taylor, of Illinois, was engaged as Field Entomologist, under the direction of Prof. Gillette. The work was more especially confined to Mesa county, although it was planned on a broad enough scale to take up other counties if time permitted. It was thought best, however, to confine the work to a relatively limited section until it was found that it could be broadened. As a matter of fact, Mesa county alone took the complete energies of the force, and no systematic work was done outside. Some attention was given to Delta and Montrose counties, and enough

so as to keep in touch with the problems of those regions, with the hope of taking up the work there during another year. In addition to the work of the Field Horticulturist and Entomologist, arrangements were made so that investigation of the seepage question was also taken up, and an investigation carried on for a part of the season in conjunction with the other work of the fruit investigation. This was conducted by Mr. F. L. Payne and Prof. House, and directed to find, first, the source of the seepage, where it had been injurious, and then, based on that, to determine the remedy. Some important lessons have been learned which will be fruitful, and will result in a benefit in this way. The total expense of this investigation was estimated to be $5,000 for the calendar year. That amount has not yet been expended, but apparently will be before the end of the fiscal year. If the expense of the seepage investigation is included, the total expense will be over $6,000. For the coming year, with the extension of such work, this would require nearly $10,000.

CO-OPERATIVE WORK WITH THE DEPARTMENT OF AGRICULTURE.

The work of this kind which has attracted the most attention is the horse breeding work, in connection with the Department of Agriculture. For this purpose, the Department of Agriculture provided a horse with an excellent record, and a number of mares also with excellent records. The Department of Agriculture furnished these at a total cost of about $15,000. There were also some gifts.

The provision in the State appropriation for animal industry was rendered available for the construction of a barn, and the total amount put into this barn for this purpose was slightly above $5,000. The college has also furnished pasture ground some three miles west of the Station, and has found it necessary to buy more during the year. There are now a number of excellent colts. The Department of Agriculture contributes $1,000 for the minor expenses of the Experiment. This is to go into equipment, but as the rules for auditing bills are troublesome for the purchase of such materials, the Department contributes this amount as a part of the salary of the Professor of Agriculture, with the understanding that the College will use the corresponding amount toward the minor expenses of the experiment. The Department of Agriculture also pays the salary of a groom, and also meets a number of minor expenses. The work calls, however, for funds from the College.

Under the agreement with the Department of Agriculture, the colts may be sold, except such as may be selected to continue the work. The proceeds from these colts go into the maintenance of the experiment. It is, therefore, hoped that the revenue derived from this source may materially aid in the cost of the experiment.

LOCO INVESTIGATION.

The loco investigation at Hugo has been in co-operation with the United States Department of Agriculture. It is an

outgrowth of previous work done by us with Mr. Payne, when we reached the conclusion that the loco problem needed to be taken hold of on a much more extensive scale. Co-operative arrangements were made with the Department by which we furnished the animals, the services of the Veterinarian, while the Department kept a man and maintained the work. The cost has been principally for the animals. At the end of last winter there were six horses and six cattle, and these were increased by purchase until there were 25 cattle and 25 horses. Of these a number have died during the season, so that at the time the invoice was made, December 1, there were 21 cattle and 13 horses. These are to be put at pasture, and a few have been brought here for better care and to test various remedies and the effect of good feed. The cost has been borne by the special State appropriation. It has amounted as a whole to $1,152.64. The Department of Agriculture feels that they are enabled now to find the cause.

The Experiment Station, through the appropriation of the Legislature, provided a number of cattle and also horses, which were used as the subjects. Careful studies were made by Dr. Marsh. The first and most important step was to attempt to determine conclusively whether the plant was the cause of the loco disease. While there has been a good deal of assertion, and a great many who are convinced either that the plant is or is not, the connection between the disease and the plant had not been so positively determined that it was safe to assume. The test of Dr. Marsh included not only the full tests on the animals, but also a study of the plant, and an attempt to determine a poison in the plant by physiological tests. Dr. Marsh reports that the results of the loco investigation of the past two seasons has substantiated the following things:

"1. In our laboratory in Washington a poison has been definitely separated from the loco plant, and is now being subjected to more complete pharmacological and chemical investigation.

"2. In the field work we have demonstrated definitely the connection of the loco plant with the loco disease, and we have determined to some extent the relative danger of the different kinds of loco plant.

"3. We have also determined definitely the pathological lesions that accompany loco poisoning, so that we can by post-mortem examination make pretty exact diagnoses of the cases.

"4. Considerable work has been done in the way of experimental dosing, but so far without final results.

"5. Considerable attention has been given, and with some success, in investigation methods of exterminating or reducing the number of loco plants.

"It seems to us that the work of the next season must be confined to more detailed investigation under these last two

heads. This, of course, is the practical end of the loco problem, and the solution of the possibilities of dosing, and the possibilities of the destruction of the loco weed would mean the solution of the whole problem."

Under the State appropriation of 1905 for animal industry, of the total appropriation of $10,000, about $5,000 was expended, as mentioned, for stables for the co-operative work with the government. A portion was used in the loco co-operative work, and Prof. Carlyle chose to use the remainder in the expenses in a test to determine the economic conditions of taking range stock and feeding. He has selected a number of calves. One set is brought to the Station at one year old, and fed; a second set remains on the range for two seasons, and a third set for three seasons. Each set is then to be brought to the Station and fed, and finally, when sold, the comparison in the size and gain is to be made.

THE WORK IN PLANT INVESTIGATION.

A considerable co-operative work was taken up by Prof. Olin, and a good deal of energy given to the dissemination of Durum wheat, with a result of a large increase in the crop grown. The work of a number of years in the development of improved wheat and oats in the San Luis valley resulted in the spreading of improved grains, and promises practical results. Very interesting and valuable tests were made with grains and alfalfa.

The fund appropriated for potato and root crop investigations was too small to be of much value in itself, but when aided from other sources, it was possible to employ a potato specialist, Mr. E. R. Bennett, who gave his whole time to the study of the potato industry and the improvement of potatoes. For a part of the season, his headquarters were at Greeley. This has resulted in Bulletin No. 117.

PUBLICATIONS OF THE YEAR.

During the year the Station has issued bulletins from 107 to 116, inclusive, five press bulletins, Nos. 24 to 28, inclusive, and three reports and special bulletin No. 100. The regular bulletins had a total of 192 pages, press bulletins ran from two to four pages each, making a total of 16 pages, and the reports, a total of 478 pages. The edition of the bulletins ran from 3,000 to 10,000. The reason for the publication of three reports was because two reports had not been published at the time they were made because of the stress of funds when the printing fell upon the Station. The total number of pages obtained by multiplying the number of the edition by the number of pages in the bulletin is nearly 5 million pages; leaving out bulletin 100, the total is about 2 million pages.

In this list is bulletin 100, which has been the subject of a note in the annual reports for several years. It is on the Flora

of Colorado. It is a credit to the Station and to the College. While it is a bulletin that will not be sought by the ordinary user, yet it will reach circles that could not be reached by the ordinary bulletins, and will give credit to the Institution and be of value to the State.

BULLETINS ISSUED DURING YEAR 1906.

No.	Pages.	Edition.	Total No. of Pages.
107	8	9,500	76,000
108	18	9,500	171,000
109	12	8,500	102,000
110	16	10,000	160,000
111	12	9,500	114,000
112	8	8,500	68,000
112	32	9,500	304,000
113	46	10,000	460,000
115	24	9,500	228,000
116	16	3,000	48,000
		87,500	1,731,000

PRESS BULLETINS.

No.	Pages.	Edition.	Total No. of Pages.
24	2	3,000	6,000
25	4	3,000	12,000
26	4	8,500	34,000
27	4	9,000	36,000
28	2	3,000	6,000
		26,500	94,000

REPORTS.

No.	Pages.	Edition.	Total No. of Pages.
14 (1901)	54	750	40,500
16 (1903)	40	750	30,000
18 (1905)	65	1,250	80,000
		2,750	150,500

The list is as follows:

No. 100. Flora of Colorado, by Dr. P. A. Rydberg.

No. 102. Feeding Steers on Sugar Beet Pulp, Alfalfa Hay and Ground Corn, by W. L. Carlyle and C. J. Griffith.

No. 103. The Thorough Tillage System for the Plains of Colorado, by W. H. Olin.

No. 104. A Rust-Resisting Cantaloupe, by Philo K. Blinn.

No. 105. A New Apple Rot, by B. O. Longyear.

No. 106. Pruning Fruit Trees, by Wendell Paddock.

No. 107. Peach Mildew, by O. B. Whipple.

No. 108. Development of the Rocky Ford Cantaloupe Industry, by Philo K. Blinn.

No. 109. Cultural Methods for Sugar Beets, by W. H. Olin.

No. 110. Alfalfa, by W. P. Headden.

No. 111. Alfalfa, by W. P. Headden.

No. 112. A Hopperdozer, by P. K. Blinn.

No. 113. Larkspur and Other Poisonous Plants, by Geo. H. Glover.

No. 114. Insects and Insecticides, by C. P. Gillette.

No. 115. Fertilizer Experiments With Sugar Beets, by A. H. Danielson.

No. 116. The Cottony Maple Scale, by S. A. Johnson.

The bulletins are now ordinarily issued in editions of 9,000. In cases, such as seem to be of more than ordinary interest, 10,000 is printed. Technical bulletins may be printed in an edition of 3,000 or less.

INVESTIGATIONS OF THE YEAR.

In most cases, the investigations carried on during the year have been continuations of work previously in progress, or development that has come as a consequence of previous work. The opportunities in the State are so great that there is a constant tendency to make much more extensive plans than can be carried out. The interference, with other duties of the College, of extension work, also prevents the completion of as much work as contemplated, and the same result is caused by the fact that every investigation broadens and extends as the investigation proceeds.

The essential method has been for the lines of investigation to be made by the heads of the different sections and submitted to the Director for co-ordination or suggestion. It has not been the custom for the Director to materially change the plans except as might be necessary to agree with general lines or to fit in with the work of other sections. The Director has, however, exercised the discretion of preventing duplication of work. Under the Adams act in the future it will undoubtedly be necessary for closer control than has been customary in the past.

Outlines of the work of the past year as approved have been as follows:

OUTLINE OF WORK FOR IRRIGATION ENGINEERING SECTION, 1906.

1. Meteorology as hitherto.

The development of lysimeter records, that is, the flow of water through soils.

3. Evaporation through soils under different conditions.

4. The irrigation survey of Colorado. This to include an examination of the State, taking up one valley at a time; a description and map of the canals and study of the methods of irrigation, of the peculiarities of canals as related to local situation and to crops, suggestions as to improvements, and study of such questions as may be found to be desirable for that locality, as, for example, water supply, drainage, storage, etc. This would require several years, but reports and bulletins would be issued as they proceed.

5. The application of water to crops. This has resulted in the past in the studies of the duty of water. Additional equipment of self-recording instruments makes it possible to take this up on a larger scale, and with the variety which is necessary to secure good results. Former co-operative trials have not been entirely satisfactory, but such trials have been necessary from the lack of instruments which now is partially remedied.

6. In connection with the Western Slope fruit investigation, to take up the question of seeped lands in the vicinity of Fruita and Grand Junction. This will require a number of visits, and quite probably a special man for several months.

L. G. CARPENTER.

OUTLINE FOR ENTOMOLOGICAL SECTION, 1906.

1. Collecting and rearing insects to determine food, habits, life histories and Colorado fauna. (Continued work.)

2. A study of sugar beet insects. (Continued work.)

3. Habits and remedies for potato flea beetles. (Continued work.)

4. A study of the habits and remedies for plant lice, with special reference to the woolly louse of the apple.

5. A study of loco insects.

6. A field experiment on the Western Slope to test remedies for the codling moth.

7. *Apiary.*

(a) A continuation of the study to determine relation of bees to apple and pear blight.

(b) Testing different strains of the honey bee.

C. P. GILLETTE.

OUTLINE FOR CHEMICAL SECTION, 1906.

I. Digestion experiments with sheep. (Continued.) Will be finished about midsummer. This is a continuation of studies already reported in bulletins 39 and 93.

II. Study of alkali as occurring in Colorado. (Continued.) This is a study as related to soils and irrigation questions.

III. Methods of extracting beeswax. This work is nearly done, and will be ready to report some time during the year.

IV. Deterioration of barn yard manures. (Continued.) This investigation is to be carried on for several years.

V. Waters of irrigation. This is a continuation of work hitherto begun, especially in the San Luis valley.

VI. Miscellaneous work.

W. P. HEADDEN.

SECTION OF HORTICULTURE AND BOTANY.

OUTLINE OF WORK FOR THE YEAR 1906.

Potato. Testing varieties. Breeding. Diseases.

Plant diseases in general.

A study of horticultural conditions.

Forestry.

FARMERS' FRUIT CO-OPERATIVE ORGANIZATIONS.

To take up the study of the various Farmers' Fruit Co-operative Organizations in the State as instances of organization and co-operation. To study the causes of organization, the methods, expenses and financial results.

To take up these organizations one at a time and make a study of them, and of the Farmers' Co-operative Organizations, of which the cantaloupe organization will be a particular type.

HORTICULTURAL SECTION.

POTATO INVESTIGATIONS: GREELEY.

The principal line of work will be to discover why potatoes run out, and in order to do this one should be with the crop practically the entire season. Irrigate and cultivate if need be, anything to become thoroughly familiar with the growth of the potato plant. This will necessitate a study of all phases of potato cultivation.

Insects and diseases should be studied at the same time.

Selection of seed potatoes from individual hills to be made in the field in the fall.

Data to be collected during the season for a bulletin on potato industry, to be published next winter.

W. PADDOCK.

WESTERN SLOPE HORTICULTURAL INVESTIGATIONS.

OUTLINE OF WORK FOR THE HORTICULTURIST.

Every orchard in Mesa county must be visited as soon as possible and inspected, particular attention being given to spraying pear blight, crown gall, wolly aphis, and all orchard pests; cultivation, pruning, irrigation, and, in fact, all horticultural operations. An orchard survey will be conducted at the same time.

Thus far Mesa county has been almost free from pear blight, but unless all signs fail it will do great damage there next sea-

son, unless means are taken, to prevent. There should be a strong effort made to induce all orchardists to destroy all traces of blight before spring opens.

Special: Experiments to control the new apple and pear rot, *Alternaria.*

W. PADDOCK.

TREE PLANTING EXPERIMENT WITH CATALAPA SPECIOSA AND BLACK LOCUST.

Purposes. To determine the adaptability of these two species, as utility trees, to the different localities in this State, and to obtain data for guidance of tree planters.

To encourage and educate the public in the matter of tree planting for posts, poles and fuel, by means of demonstration plantations.

Trees Selected. The trees selected are the hardy or western catalpa (Catalpa speciosa) and the Black Locust (Robinia pseudacacia). They were chosen because of their general utility qualities, viz.: ease of establishing, hardness, rapid growth, great durability when in contact with the soil and good full value.

Plan of the Experiment. (a) A plantation of 300 trees of each species to be established in each of twenty representative localities in the State.

(b) Each plantation to be put in charge of some responsible person who shall volunteer to furnish the ground, set the trees and irrigate and cultivate them according to instructions.

(c) The Experiment Station to furnish the trees free of expense to the person in charge, to supervise the planting of the trees, and to leave the plantation entirely in the possession of the owner of the ground at the end of ten years.

Details of the Plantation. The trees of both species to be planted in rows six feet apart, with the trees four feet apart in the row, thus covering about one-third of an acre. The rows to extend usually north and south, and the area covered to be not more than twice as long as broad; a wind break to be used where thought necessary.

PROPOSED LINES OF INVESTIGATION IN ANIMAL HUSBANDRY FOR THE YEAR 1906.

1. A comparison of the different systems of *wintering steers in Colorado*. The plan is, in brief, to select sixty uniform steer calves from three different parts of the State at weaning time this fall, fifteen of them from a ranch on the western slope, a like number from a ranch on the plains, and thirty head from a ranch on the eastern slope of the foothills. Five of these calves from the plains, five from the western slope and ten from the ranch in the foothills will be brought to the Experiment Station this fall and put on feed. The remaining ten steers on the plains will be wintered almost entirely on the range; the remaining ten steers on the western slope will be wintered with the ranchman from whom they were purchased, on a combination of range and hay feeding, while the remaining twenty steers of the lot selected on the eastern slope of the foothills will be wintered entirely on native hay.

Next fall, five more of these steers from the western slope, a like number from the plains and ten head from the foothills of the eastern slope will be brought to the College and put on similar feed to that given the first three lots, and the succeeding fall the remaining twenty head of the three lots will be brought here and put on feed until ready for market as three year olds.

The object of this line of work is to compare the different systems of wintering cattle, as it affects the cost of beef production, the quality of the meat, and the development of the animals generally.

2. A comparison of roots, hay and grain with hay and grain alone for wintering steer calves.

3. The value of sugar beets in fattening young pigs. In this experiment we will use twenty-four young shoats. Twelve of these will get a mixture of ground corn, ground barley and wheat shorts. The remaining twelve head of similar breeding and like weight will get just half the amount of this same combination of feeds as the first lot received, with what sliced sugar beets in addition they will eat, the object being to determine the value of sugar beets in fattening pigs in comparison with an all-grain ration.

4. An experiment to determine the cost of wintering brood sows, and the effect upon the offspring of wintering brood sows on sugar beets and alfalfa hay, as compared with a grain ratio and alfalfa hay. We will have ten head of brood sows available for this experiment. Five of these will be fed sugar beets and al-

falfa hay, and the others will have a mixture of grain for a ration, and alfalfa hay.

W. L. CARLYLE,
Agriculturist.

ASSISTANT AGRICULTURIST.

GRAINS AND GRASSES.

PLANS FOR YEAR.

I. Grain Investigation Work.
II. Forage and Grass Investigation Work.
III. Sugar Beet and Other Root Investigation Work.
IV. Seed Competition Work.
V. Publication of Data Obtained.

VETERINARY SECTION.

PLANS FOR YEAR.

(1) To continue the investigation of loco weeds and disease in conjunction with the Department of Agriculture.

(2) To investigate poison weeds other than loco and contagious diseases in general over the State.

(3) Printing of bulletin on Larkspur and Other Poisonous Plants.

ARKANSAS VALLEY FIELD AGENT.

Alfalfa, Beets and Cantaloupes. The specific lines of each as follows:

Alfalfa. 1. Improvement by seed selection, extending the present nursery, with planting of seed selected this year, and other promising strains. This work to be done in co-operation with Prof. Olin.

2. A field study and the investigation of conditions and methods of securing the best yields of alfalfa seed. This work might be planned to complete for an early publication, also with a view of extended investigation, if the results warranted.

3. Continued co-operative work with Prof. C. P. Gillette investigating the insects injuring alfalfa, especially affecting seed production.

Beets. The continuation of the efforts to develop a disease resisting beet. Also a similar outline for investigating beet seed growing as that planned above for alfalfa, though the field for observation might be smaller. The two lines could be worked in conjunction.

Cantaloupes. 1. Continuation of the rust-resisting cantaloupe investigation; this could largely be done in co-operation with growers. Perhaps a small plot on the Station property.

2. Improvement of cantaloupe by cross-breeding small test plot.

The general plan to carry out the above line of work would be field work in the vicinity of Rocky Ford and plat work on the Station property at Rocky Ford. The field work also to include several trips up and down the Arkansas valley to investigate alfalfa seed growing. Possibly a trip as far east as Garden City, Kansas, which is a large alfalfa seed producing section.

The investigation of beet seed growing is one of large interest to the State, and to what extent it should be taken hold of is a question better considered than recommended.

I. THE CANTALOUPE INDUSTRY IN THE ARKANSAS VALLEY.

To take up this, and especially the question of Farmers' Cooperative Organizations; to obtain complete data of the original cause of organization; developments from year to year; methods of organization and changes that have taken place, together with results; to obtain data as complete as possible by correspondence and by records, with the idea of issuing as one of a series of bulletins on the Farmers' Co-operative Organizations.

II. STUDY OF CULTURAL METHODS OF SUGAR BEETS.

To take up the methods of growing beets in the Arkansas valley; to spend a great deal of time in the field visiting the beet fields with the agricultural men of the different factories; to especially study the difference in cultivation and yield, and to trace them back to the cause which may have produced them.

To take up more especially in this connection the Arkansas valley as about as much as can be done in one season, but to make several trips into the beet growing sections and other parts of the State, and to give to this matter the time available from the cantaloupe and alfalfa investigations to be carried on at Rocky Ford.

PHILO K. BLINN.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1906.

RECEIPTS.

Dr.	U. S. Fund	Special Fund	State Fund	Totals
From the Treasurer of the United States as per appropriation for the fiscal year ending June 30, 1906, as per act of Congress approved March 2, 1887	$15,000.00	....	....	....
Balance on hand July 1, 1905	....	$ 686.05	....	....
Miscellaneous	....	2,588.23	....	....
*State appropriations	....	....	$14,000.00	....
Total receipts				$32,274.28

DISBURSEMENTS.

Classification	U. S. Fund	Special Fund	State Fund	Totals
Salaries	$10,234.50	$ 1,168.29	$ 180.00	$11,582.79
Labor	446.70	287.95	963.73	1,698.38
Publications	1,677.52	997.78	503.60	3,178.90
Postage and stationery	379.42	39.79	258.98	678.19
Freight and express	129.41	21.16	247.82	398.39
Heat, light, water and power	4.35	5.70	....	10.05
Chemical supplies	....	....	....	....
Seeds, plants and sundry supplies	226.95	22.88	630.07	879.90
Fertilizers	....	....	3.10	3.10
Feeding stuffs	....	....	541.37	541.37
Library	169.27	26.00	....	195.27
Tools, implements and machinery	....	18.65	38.80	57.45
Furniture and fixtures	494.42	134.60	33.80	662.82
Scientific apparatus	236.11	242.79	72.79	551.69
Live stock	110.00	....	1,679.63	1,789.63
Traveling expenses	807.52	260.61	320.19	1,388.32
Contingent expenses	83.83	35.00	6.00	124.83
Buildings and repairs	....	13.08	6,155.60	6,168.68
Total expended	$15,000.00	$ 3,274.28	$11,635.48	$29,909.76
Balance			2,364.52	2,364.52
			$14,000.00	$32,274.28

*This is a special appropriation by the State Legislature for two years—from December 1, 1904, to November 30, 1906, inclusive.

INVENTORY, AGRICULTURAL EXPERIMENT STATION, 1906.

DIRECTOR'S OFFICE.

Office fixtures and equipment	$ 1,689.38	
Stationery and supplies	417.85	
Half tones and zinc etchings	455.70	
Library	2,410.00	
		$ 4,972.93

METEOROLOGICAL AND IRRIGATION ENGINEERING SECTION.

Meteorological instruments	$ 701.55	
Office fixtures	254.95	
Stationery, books, maps, etc	56.65	
Irrigation and hydraulic apparatus	449.80	
Photo supplies and negatives	262.19	
Tools, etc., for soil work	180.85	
Miscellaneous	367.18	
		$ 2,273.17

ENTOMOLOGICAL SECTION.

Laboratory and office supplies	$ 329.53	
Entomological supplies	140.90	
Insecticides and insecticide apparatus	283.10	
Apiary	118.45	
Microscopic apparatus	592.25	
		$ 1,464.23

CHEMICAL SECTION.

Calorimeter	$ 210.00	
Polariscope	180.00	
Pulp machine and juice press	70.00	
Three balances	250.00	
		$ 610.00

HORTICULTURAL SECTION.

Photographic apparatus	$ 64.35	
Instruments	114.00	
Herbarium	1,652.00	
Tools	30.80	
		$ 1,861.15

AGRICULTURAL SECTION.

Implements and tools	$ 485.50	
		$ 685.50

VETERINARY SECTION.

Kodak	$ 18.00	
Stationery	2.00	
Stock at Hugo (loco experiment)	408.00	
		$ 428.00

ROCKY FORD SUB-STATION.

Forty acres of land, with water rights (title conditional)	$ 7,000.00	
Buildings and improvements	1,484.00	
Farm machinery and tools	678.75	
Office furniture and fixtures	30.80	
Camera and photo supplies	30.00	
		$ 9,223.55

CHEYENNE WELLS SUB-STATION.

One hundred and sixty acres of land (title conditional)	$ 800.00	
Fencing	110.00	
Three thousand feet galvanized iron pipe, in ground	30.00	
Dwelling house and barn	750.00	
(U. P. Railway property at station, $18.)		$ 1,690.80

WESTERN SLOPE FRUIT INVESTIGATION.

Horse	$ 110.00	
Implements and tools	136.50	
Office furniture and fixtures	157.35	
Camera and photo supplies	69.40	
Negatives	100.00	
Insecticides	3.25	
		$ 576.50
Total		$23,785.83
Total Adams Fund inventory		4,157.36
Total		$27,943.19

REPORT OF THE HORTICULTURIST AND BOTANIST.

To the Director:

Since my last report the work in this section has been divided into several sub-sections, as follows:

Forestry, in charge of Prof. B. O. Longyear.

Western Slope Fruit Investigations, in charge of Prof. O. B. Whipple.

Potato Investigations, in charge of Mr. E. R. Bennett.

Professor Whipple, formerly assistant in Horticulture, was placed in charge of the work on the Western Slope, leaving here in April. His successor, Professor Paull, did not assume his duties until September, consequently the work here has been considerably hampered.

Mr. Bennett began his work with potatoes in April. It is too soon to expect definite results from this work, however; a number of interesting experiments are well under way.

Perhaps the most important departure which the College and Experiment Station has yet undertaken so far as the Horticultural section is concerned is the inauguration of field work on the Western Slope. Both Mr. Taylor and Mr. Whipple have met with good results with their work, and the constant demands on their time shows that the efforts of the College are appreciated.

More detailed accounts of the work of these various sub-sections will follow.

Our own time has been largely occupied with teaching, executive work, correspondence and occasional visits to the fruit sections of the State. A new plant disease has made its appearance in the form of a bacterial blight of alfalfa. This disease appears to be new to science, and in some restricted localities has resulted in the practical destruction of the crop. We have planned to make a thorough study of the disease and hope to discover some method of combatting it.

Material for two bulletins has been collected, as follows: "Fruit Associations" and "The Red Raspberry Industry." We hope to have these ready for publication before the close of the year.

Forestry. A co-operative experiment in tree planting was begun last spring, which originally included twenty farmers in as many localities. Twelve thousand trees were to be distributed in lots of six hundred each. But the demands for trees were so great that the plans were extended till forty-seven co-operators included and 22,200 trees distributed. Reports from these men show that in the great majority of instances these trees have been well taken care of and a good growth is the result.

Potato Investigations. Mr. Bennett began his work with potatoes in the latter part of April. He has visited all of the potato growing sections of the State, and made a systematic study of the culture of the crop and the general status of the industry. A bulletin on this phase of the work is now in preparation.

Several experiments in seed selection in an effort to produce more uniform and more stable varieties are well under way.

Western Slope Fruit Investigations. This work was inaugurated last spring by the appointment of Mr. O. B. Whipple as Field Horticulturist, and Mr. E. P. Taylor, Field Entomologist. I need only mention here that this work has proven most satisfactory from all standpoints. The demands for advice and assistance in various ways have been greater than could be met, even had no experimental work been attempted. The results of one season's experiments are not usually conclusive, but some of the things which these men have determined even in this short time will be worth many thousands of dollars annually to the fruit growers of Grand valley.

Respectfully submitted,

W. PADDOCK,
Horticulturist and Botanist.

SUB-SECTION OF WESTERN SLOPE FRUIT INVESTIGATIONS.

My work in connection with the Station as Field Horticulturist dates from April 1, 1906, and practically all of this time has been devoted to the study of orchard conditions in Mesa county. During the season I have made two trips to Delta county to investigate the conditions there. I find it nearly, if not quite, impossible, to divide my time to any great extent with outside counties.

In my work I have given especial attention to plant diseases, cultivation, watering, pruning and the collection of data on the fruit industry.

The interest taken in the work by the growers has been very gratifying, and at no time have we experienced any difficulty in securing the co-operation of careful growers in carrying on experiments. The success of our work depends to a large extent upon this friendly co-operation of the fruit growers. Our correspondence with growers has not been all we desired, but will no doubt increase as we become better acquainted and the plan of our work better known. Requests for information have been numerous, but, on account of the limited time spent in the office, some growers have no doubt become discouraged in trying to catch us by telephone. We have tried to spend as many evenings as possible in the office, where we hope the growers will learn to catch us.

The orchard survey work has not progressed as rapidly as we at first hoped it would, on account of the time required for other investigations. This survey work has been carried on in connection with other work as far as possible. This part of the investigations can no doubt be pushed more rapidly during the remainder of the year, and while the summer season is no doubt the ideal time for this work, I think the object of the survey can be accomplished during the winter season.

Observations on plant diseases have been very interesting, and some important conclusions have been reached.

In three orchards where experiments were carried on in spraying for Alternaria very satisfactory results were obtained. Bordeaux as a fungicide was used in connection with arsenate of lead and arsenite of lime, being careful in each case to have some check trees where the effect of these insecticides on the fruit and foliage when used alone might be observed. These experimental blocks contained Kieffer pears and Gano and Ben Davis apples, and were so divided as to show the possibility of controling Alternaria with one winter application, with one winter and one summer and with two summer applications of Bordeaux

mixture. For all summer applications half strength Bordeaux was used, and were with the first and second codling moth sprays. The following conclusions were reached:

That Alternaria is, in most cases, a secondary factor in causing the decay of fruit, and in this locality at least follows spray injury to a large extent, though it may follow bruising or codling moth injury.

That the most satisfactory method of controlling it lies in choosing a reliable arsenical poison.

That the Kieffer pear can not, in this locality, be sprayed with any degree of safety with other than a standard or tried brand of arsenate of lead.

That if Ben Davis and Gano apples are to be sprayed with arsenite of lime, special care should be given to its preparation, and a good clear day selected in which to apply it.

As a secondary observation it is found that Bordeaux mixture prepared by using two pounds copper sulfate, four pounds lime and fifty gallons of water will russet Ben Davis and Gano apples, though not to any serious extent, if used on any other than a clear day, and even then russeting may occur on the shaded portions of large trees.

Though only a trace has been found in this county, peach mildew has attracted more attention than usual in other localities this season. This is probably on account of the unusual amount of rain during the early part of the summer. No experiments have been carried on under my directions, but observations made in orchards sprayed by careful orchard men show that one thorough summer application of dilute Bordeaux, 2-4-50, will clean up a badly infested orchard. The disease is capable of ruining a crop in a short time, and prompt action is an important point in fighting this disease.

Gummosis in peach trees has been called to my attention in several orchards, and where not too for advanced, a vertical slitting of the bark seems to bring relief and leads to the recovery of the tree. The use of a sharp knife in cutting through the bark about the affected trunk or branch seems worthy of further trial.

Two apparently distinct forms of root rot found working upon the apple seem to be important enough to require careful study the coming year. One form which is proving the more destructive of the two works exculsively, I believe, on the apples of the Ben Davis type, while the other shows no preference for varieties nor is its presence in the orchard followed by such rapid spread and destruction.

Some experiments have been undertaken in thinning apples to determine the average amount of fruit trees of various ages will produce and the effect of thinning out the color of the remaining fruit and the crop of the ensuing year.

Problems for the ensuing year I believe are:

Pear blight and its control, giving special attention to the form known as blossom blight.

Peach mildew and the effects of winter spraying with Bordeaux mixture and lime-sulphur washes.

Grape mildew (U. spiralis) and methods of control.

Tests in pruning grapes by various methods in hopes of finding a trellis method of training which will hold the fruit off the ground and still allow of the grapes being taken down and covered in winter.

Observations on the amount of irrigation best adapted to grape growing.

And a careful study of the two forms of root rot mentioned above, to determine the nature of the disease and remedies if possible.

Respectfully submitted,

O. B. WHIPPLE,
Field Horticulturist.

SUB-SECTION OF FORESTRY.

A CO-OPERATIVE EXPERIMENT IN TREE PLANTING.

An extensive experiment in co-operative tree planting has been started during the past season, with two species of utility trees—the Common or Black Locust (Robinia pseudacacia) and the Hardy, or Western Catalpa (Catalpa speciosa).

The primary purpose of the experiment is to enable us to secure data as to the adaptability of these two species of trees in different parts of the State, and furthermore to place object lessons in the formation of artificial timber plantations before the farmers and land owners of Colorado.

To this end notices were sent to the newspapers throughout the State, calling attention to the desirability of planting trees for posts, poles and fuel and calling for volunteers to co-operate with the Station in the experiment. To each volunteer was sent a printed leaflet giving the purposes, conditions, and plan of the experiment together with some suggestions for preparing the land and setting the trees for a timber lot. Each applicant for trees was also asked to give the altitude and a description of the land, the use of which was offered for this purpose.

According to the conditions of the experiment, as originally planned, each co-operator should furnish the land free of charge, plant the trees and care for them according to instructions, and report upon their condition whenever requested. The Experiment Station should furnish the trees free of charge, except transportation charges, and give occasional supervision and advice as to their care. It is intended to carry the experiment over a period of ten years, at the end of which time the Station will relinquish all claims upon the plantation.

At first it was planned to establish one plantation of three hundred trees of each species in each of twenty representative localities of the State. For this purpose six thousand trees of seedling locust and an equal number of two year old catalpas were purchased in 1905, and planted on the Station grounds, where they were allowed to grow one season. So many applications were made for trees, that it was impossible to supply all from this stock. An extra appropriation, however, was secured by which enough additional stock of the locust was purchased to supply 500 trees to such of the other applicants as seemed to be favorably situated for the purposes of the experiment. In all forty-seven lots of trees have been placed in the hands of co-operators representing thirty-five different localities and twenty-four counties.

Before shipping the trees, Press Bulletin No. 25, Instructions for Co-operative Tree Planters, was prepared and sent out.

This contains detailed instructions as to location, and preparation of the soil, spacing, heeling in, trimming, planting, irrigating and cultivating.

The catalpa seedlings, when planted on the Station grounds, were two years old, and about eighteen inches high. They were cut back to about one foot in length, and after being root pruned, were planted with ditching spades in rows two feet apart. The locust seedlings were only about one foot long when received and were cut back and planted in the same manner as the catalpas. The catalpas made a growth of about ten to fifteen inches; the locusts an average of about four feet. During the winter of 1905 and 1906, which was very severe on all young trees, both species were killed back nearly to the ground; the locusts being less injured than the catalpas.

The second lot of locust seedlings, purchased in the spring of 1906, were of vigorous growth and about two and three feet high. They were shipped from the nursery to the Station where they were divided into lots of 500 and baled for shipment to the planters.

Respectfully submitted,

B. O. LONGYEAR,
Assistant Botanist.

SUB-SECTION OF POTATO INVESTIGATIONS.

The investigation of the potato industry in Colorado was begun the latter part of April, 1906. Since then the various potato districts of the State have been visited, and a systematic study has been made of the methods of culture, irrigation, insect pests and diseases of the Greeley district and the other districts as far as time has permitted.

Experiments to determine the effect of changing seed from one location to another have been started. Two sacks of Red Improved Peachblow potatoes were selected from the storage cellar of Mr. Edgerton, of Carbondale. One of these was planted there. The other was sent to Greeley and planted on Mr. E. R. Bliss' place, near Greeley. Two sacks each of Late Ohio, White Pearl and Rural New York No. 2 were selected from bins at Greeley, one of which was planted there, while the others were sent to Carbondale and planted.

The work of improving and fixing the existing varieties by selection has been started in co-operation with potato growers in different places. A quantity of a new variety from Scotland, the Delmany Beauty, which is being grown by Mr. Grubb, at Carbondale, was divided into two types, one a round potato, the other long, and planted separately to observe the effect on the types.

Ten sacks of White Pearl potatoes have been selected from a field on the farm of Mr. Bickling, near Greeley, and stored in his cellar. The potatoes in this field were of a superior type to most fields, owing to the effects of two years' careful selection by the grower. Many hills contained potatoes, all of which were of a desirable type. None but the best tubers from these desirable hills were selected. Because of the tendency of potatoes to "run out" when planted more than two or three years on the irrigated land of Greeley, growers do not keep the same seed more than that time, and by changing, the gain from the two years previous selection is lost. The plan is to have these selected potatoes planted on the unirrigated land of the Arkansas divide, and at the end of one or two seasons, bring them back to the Greeley district. If this should prove to be practical, the type of potatoes can be much improved.

It is thought possible by careful selection to avoid the tendency of potatoes to "run out" on the irrigated lands. With this idea in mind, seven sacks of potatoes were selected from a field of new land on the same farm near Greeley. These were grown from Divide seed, which, like most seed brought from outside the district, is mixed as to variety as well as type.

Of the Improved Peachblow potatoes brought from Carbondale, one sack has been selected for seed for next year and a sack of Carbondale seed will be planted with them so as to observe the effect of the acclimatization on them.

One acre of land on the Foy place, two miles east of Fort Collins, was rented for experimental work with potatoes. The land was planted with small plats of about fifty varieties of seedlings and European varieties, obtained from the Department of Agriculture at Washington. The formalin and corrosive sublimate treatment were both used on plats of Pearls and Rural New York No. 2, and one plot of the land was given an application of copper sulphate at the rate of 35 pounds per acre to ascertain the effect on potato scab or *Rhyzoctonia.*

Measurements have been made as to the amount of water used by irrigation to grow an acre of potatoes. Special attention has been give nto the diseases of potatoes, especially *Rhyzoctonia,* as to its effect on yield and quality of the crop and to the conditions of culture and irrigation that have tended to make the disease less or otherwise. Investigation along the same line is now being carried on in the laboratory.

It is the opinion of the writer that cultural methods have much to do with the control of our soil disease, and consequently the success of the potato crop. It is proposed to carry on quite extensive experiments in co-operation with growers in different parts of the State to determine the effect of deep versus shallow cultivation.

Respectfully submitted,

E. R. BENNETT,

Potato Expert.

REPORT OF THE ENTOMOLOGIST.

Fort Collins, Colo., Nov. 24. 1906.

To the Director:

I have the honor to present herewith my annual report of the Entomological Section for the year just closing.

The year has not been marked by any extraordinary insect outbreak unless it be the rapid increase of the green aphis and the woolly aphis of the apple tree in the orchards of the Western Slope where these insects have become an intolerable burden to the apple growers. If these lice continue their depredations unabated for a few years more in the sections where they have been most abundant the past year, there are many fruit growers who will feel like giving up the fight and taking out their apple trees.

Rather extensive experimental work has been outlined with a view to finding better methods for the control of these pests. The work includes a thorough study of the life histories and natural enemies of these insects as well as the testing of insecticide measures for their destruction.

The melon louse (*Aphis gossypii*) continues to be a serious pest in those sections of the State where water melons and cantaloupes have longest been grown in a commercial way. This insect is also a special subject of study by this section, both for the purpose of determining its food habits, and life history as well as to determine the most practical methods of keeping it in check in the melon fields. Considerable has been accomplished along this line already but our work must continue through another year at least before publishing upon it.

While the three plant lice above mentioned are being given special attention, it is thought best to do as much as possible to determine the species of plant lice that are infesting Colorado plants, both native and cultivated, and to determine, so far as possible, their life histories.

Two papers are about ready at the present time for publication upon the plant lice of the genus Chermes attacking Colorado Conifers.

The common grasshoppers (Locusts) have been usually abundant over the State the past summer and the Western cricket (*Anabrus simplex*) is reported to have done many hundreds of dollars damage to crops in Routt county the past year. The depredations are carried on at so great a distance from the Experiment Station that it makes the work of experimentation against this insect very expensive, and nothing has been done in the study of its habits or to determine the best methods for its destruction by this section except what was published in Bulletin 101. If the depredations of this insect continue, it will doubtless be ad-

visable to arrange to take up some special lines of investigation with a view of finding better remedies than are at present known to lessen its injuries.

The work of collecting the economic insects during the past year has been very largely confined to the plant lice and the insects that are associated with them either as friends or enemies.

The only scale insects of much economic importance in Colorado are the cottony maple scale, attacking chiefly the soft maple, the boxelder, and the black locust, and Howard's scale (*Aspidiotus Howardi*), most abundant upon pear, plum and apple trees. The work of the section upon the former scale was reported by Mr. S. A. Johnson in Bulletin 116 and press bulletin 27, and Mr. E. P. Taylor has been giving special attention to Howard's scale in the orchards of the Western Slope where it has been injuriously abundant in many instances to a small number of trees. Mr. Taylor expects to be able to prepare a bulletin giving full life habits and satisfactory remedies for this insect in the near future. He probably will wish to carry his investigations through another year, however, before making his report upon the work.

The oystershell scale (*Lepidosaphes ulmi*) was first taken in the State by Mr. S. A. Johnson the past year, who found it badly infesting a few lilac bushes in City Park, Denver. Mr. L. C. Bragg has since taken the same scale in several instances upon elm trees in the vicinity of Fort Collins, but in scattered numbers only in each case.

I am glad to be able still to report that the San Jose scale continues to be unknown in the orchards of Colorado.

The peach twig borer (*Anarsia lineatella*) did its usual injuries to peach trees of the Western Slope last spring. Mr. E. P. Taylor seems to have demonstrated that the injuries of this insect can be almost entirely prevented by an early spring application of arsenate of lead.

The Eastern peach borer (*Sanninoidea exitiosa*) has also been found by Mr. Taylor to be a serious pest in a few limited localities on the Western Slope. It has not as yet attracted much attention as an injurious insect in this State, but the fact that it is already injuring a few orchards, makes it important that our fruit growers be very watchful and put forth every effort to keep this serious peach enemy in check.

The observations upon fruit blossoms, and the time of the blooming of our fruit trees, that have been carried on for two or three years past are being made chiefly for the purpose of determining the relation of the varieties of fruit to the time for spraying, and to determine the flower visitants and their possible or exact relation to blight in apple and peach orchards. Considerable additional data have been collected during the past year. All of these records with additional ones, I hope to be able to collate for publication some time in the future.

The co-operative experiment with the Horticultural Section for the special purpose of determining whether or not blight

germs are carried over in honey in the bee hive is also being continued for another year.

The codling moth work that was planned for the Western Slope and which was carried on in a section where this insect had become specially destructive and abundant, were carried through by Mr. Taylor to a satisfactory conclusion, proving beyond reasonable doubt that this insect can be almost wiped out as an orchard pest in the worst infected sections of the State by two or three thorough applications of Arsenate of Lead properly applied. (See the report of Mr. Taylor given below.)

Mr. Taylor has also carried through life history records upon this insect the past season that confirm the writer's former views as to the number of broods of the moth and that will be of much value in determining the best dates for the application of arsenical sprays for the control of this insect in the Grand Valley.

Mr. Johnson's investigations of loco insects have been completed and a short bulletin can be prepared soon.

The work upon potato insects, which is also being carried on by Mr. Johnson, will need to be continued through another season.

The entomological outline from this section for the Western slope fruit investigations for the years 1906-'07 is as follows:

I. NOTES ON APPLE AND PEAR BLOOM—

A. In relation to Codling moth spray.

(a) Date of blooming of different varieties.

(b) Date of petals falling from different varieties.

(c) Date of calyx closing in different varieties.

(d) Relation of early and late blooming to setting of fruit.

(e) Position of calyx cups, up, out, down, etc.

B. Relation of bees and other insects to blight.

(a) Proportion of honey bees to all other insects visiting apple and pear blossoms; also collect and pin examples.

(b) Note condition of bloom when bees stop work.

II. SPRAY NOTES.

A. Kind of poison.

(a) Compare arsenate of lead and arsenite of lime.

B. Comparative value of different sprays at different dates.

(a) Once as blossoms fall.

(b) As blossoms fall and again in 30 days.
(c) As preceding and again in 30 days.
(d) As preceding and again in 30 days.
(e) As preceding and again in 30 days.
(f) As preceding, except that first spray (a) is to be left out.

Also note size of trees, amount of spray used, varieties, pressure, etc.

III. LIFE HISTORY NOTES. (Codling moth.)

A. Band record on at least ten trees. Observations not less than once a week.

(a) Try to determine when first eggs are laid, and when first worms enter apples, what per cent enter bloom on sprayed and unsprayed trees, the date of minimum of worms between broods. When second brood of worms begin to come down, when first brood are all down, etc.

(b) By cutting open unsprayed apples wormy by the second brood, determine what per cent really enter at blossoms.

B. Make notes on the work of others bearing on above points, the time and thoroughness of their spraying, etc.

IV. MISCELLANEOUS NOTES.

A. Woolly Aphis.

(a) Varieties most and least attacked.

(b) Extent of injury (little apples, trees killed, etc.); when first winged lice appeared, effects of the remedies that have been used, etc.

B. Howard Scale (and others).

(a) Kind of scale, variety attacked, nature of the attack, extent of injury, when first noticed, stage of insect. Notes on applications that may have been made.

C. Peach Twig Borer.

(a) Fruit tree attacked, nature and extent of injury. Try to determine broods, collect under bands. Notes on remedies.

D. Western Peach Borer.

(a) Rear all specimens possible to determine life history.

E. Apple Aphis (and others).

(a) Note if lime and sulphur or other sprays before hatching lessen lice.

F. Brown Mites.

(a) Same notes as for preceding.

G. Such other miscellaneous notes as seem to you to be of value.

Special emphasis was put upon the codling moth work during the spring, summer and fall of 1906. A greater portion of that investigation having been satisfactorily completed, and the woolly aphis and green aphis having become the two most serious pests on the Western Slope, the principal work for the coming year will be with these two lice. Such time as is unoccupied with this investigation will be devoted to carrying on other work outlined in the schedule.

I believe we are very fortunate in securing so good a man as Mr. Taylor to carry on the entomological work in the orchards of the Western Slope, and I very much hope his services may be continued another year.

The plant lice investigations of the Western Slope are only a portion of a larger scheme for the study of the habits and life histories of Colorado aphididæ to be carried on from the Central station.

The bulletins published from this section during the year just closing are No. 114, Insects and Insecticides, C. P. Gillette; No. 116, The Cottony Maple Scale, S. A. Johnson, and press bulletin No. 27, The Cottony Maple Scale, S. A. Johnson.

I am also appending a report from Mr. E .P. Taylor, entomologist of West Slope Fruit Investigations, and an index to the entomological writings of the station from its organization to the present time, all of which is

Very respectfully submitted,

C. P. GILLETTE.

REPORT OF FIELD ENTOMOLOGIST.

To the Director:

I herewith report the results of work of the field entomologist of the Western Slope fruit investigations for the year 1906.

The lines of research outlined as a guide by the Entomological Department of the station at the beginning of my duties have been adhered to as closely as possible, with an occasional broadening or deviation of experiments and investigations as the conditions of the situation presented new possibilities.

The principal lines of work for the season have been as follows:

1. Experiments upon practical methods of controlling the principal insect pests of the orchard.
2. The collection and study of other economic insects.
3. Visitation of orchards by request or otherwise.
4. Attendance at fruit growers' meetings, farmer's institutes, county fairs, etc., where questions relating to the work of this office were being considered.

The experiments conducted upon economic insects have been carried on in co-operation with the orchardmen themselves who are suffering losses from these pests. These experiments have been as practical demonstrations in each neighborhood in which they were carried on and have served as object lessons at the same time they were revealing new facts. They have been the objects of the deepest local interest. These co-operative experiments have in general proven most successful and beneficial, as evinced by the hearty support and appreciation shown. The territory covered by the demonstrative experiments has been thus far limited to points lying in the lower Grand valley, principally in the orchard sections surrounding Grand Junction, Palisade and Fruita. Numerous requests for such work have been received from other fruit sections of the Western Slope. These districts wish to have similar investigations planned for them.

The codling moth has received the greatest share of attention. Spraying experiments have been completed in five orchards of the valley, and the results successfully answer the principal questions which were being asked by orchardmen at the beginning of the season. These results, among other things, have demonstrated the fact that this important pest may be controlled by a fewer number of sprays than have ordinarily been given in this locality. The proper time to spray has been determined as well as the proper spray materials and the right way in which to do the spraying. The life history of the codling moth for this section

has been studied and the method of spraying against it planned, with the life history and habits of the moth in view.

Probably no district in the United States is better equipped with modern spraying appliances than the orchard district of Grand valley, but in spite of this fact codling moth ravages have injured the fruit of the one locality to the extent of a great many hundreds of thousands of dollars each year for some years past. This was done in spite of the fact that many orchardists gave eight or ten or even more sprayings per season. It has been determined that these failures have been due to several causes: (1) lack of thoroughness of method; (2) lack of proper spray material, and (3) lack of knowledge of the exact life history of the moth enabling them to apply their sprays at the most effective time. At Fruita experiments were conducted determining the proper time to spray, resulting in practical control of the moth in badly infested orchards with from two to three applications. In the experimental plat of this orchard sprayed three times with Swift's arsenate of lead a count of 3,971 Ben Davis apples, picked from average trees, gave but 1.8 per cent. wormy apples; from 437 Jonathan apples, from trees receiving the same treatment, 2 per cent. were wormy, and 2,683 apples from Winesap trees of the same plat gave only 1.19 per cent. wormy. Out of 4,818 Jonathan apples picked and examined from trees sprayed five times, only 99/100 of one per cent. were wormy, while picked apples from unsprayed Jonathans in the same orchard gave 78.1 per cent. wormy apples, and the majority of the crop had fallen to the ground as wormy wind-falls previous to the count. At Grand Junction the codling moth experiments were conducted upon the proper methods of application of spray; comparative values of arsenate of lead and arsenite of lime as a spray and the comparative merits of different formulæ of these insecticides. These experiments were conducted along practical lines, with economic results in view. Great pains were taken to make the tests upon an extensive practical basis in order that the results would represent the greatest accuracy possible. In obtaining the exact outcome of the work, very large numbers of apples have been given careful hand to hand inspection, as it seemed that only averages from large numbers of apples could accurately represent the true condition. In determining the codling moth percentages, over 100,000 apples were critically examined, representing upwards of 600 boxes chosen as the nearest types of the various plats under comparison. The examination and counting of this number of apples has been in itself no small task, but the results seem to more than justify the time and labor spent.

Experiments conducted at Palisade have demonstrated the great value in the use of arsenate of lead against the peach-twig borer which has caused damage to the peaches of that section.

The life history of the Howard scale of the pear has been partially worked out and the insect successfully and cheaply controlled by dormant sprays of the lime and sulphur wash. The

mite of the pear has likewise been experimented upon and a similar treatment found successful. The peach borer has been found present and experiments for its control are under way. The unusual abundance this season of all forms of aphids has made it necessary to devote some time to their injuries and treatment. A number of insecticides were tested in April against the eggs of the insect then hatching and the lime and sulphur wash found destructive to their eggs. Experiments of insecticide against the woolly aphis so universally destructive are now under way. A new injury to the tender buds of pear and apple by a minute chrysomelid beetle (*Myochrous squamosus LeC.*) was discovered and studied and some measures of control undertaken. The microscopic bee (*Trichogramma pretiosa*) infesting the egg of the codling moth was studied in relation to its benefit in our apple and pear orchards in assisting in the control of this insect. Studies were made also of lace wings and lady beetles, which are so helpful in reducing the number of woolly aphis and other aphids. Injury by ants and prairie dogs to young cantoloupes planted upon virgin land has been observed and assistance given in their control. The injury to fruit from sprays containing an excess of free arsenic has been fully investigated and is now under preparation for fuller report. Other miscellaneous notes have been made upon peach aphis, elm aphis, mosquitoes, green fruit worm, grasshoppers, round head borers, etc., and considerable material collected and preserved. An insectary for the study of life histories of insects has been maintained throughout the season.

Various new insecticides have been tested, some where the fruit growers' association desired information upon such products before making large purchases of them. In all my work an intimate and beneficial relation between the associations of fruit growers has been maintained.

Notes on fruit bloom in relation to sprays have been collected, such as the date of blooming of different varieties, the date of petals falling from different varieties, date of calyx closing, relation of early and late blooming to setting of fruit, and the direction of fruit bloom upon the tree.

An exhibit of the entomological work being done was prepared and shown at the local county fairs, attracting considerable attention.

A considerable number of horticultural meetings have been attended. Short addresses upon subjects relating to the work have been given at seven meetings held throughout the fruit sections of Mesa county by fruit growers' associations or horticultural societies. Aside from these some part in regular farmers' institute work has been taken.

Respectfully submitted,

ESTES P. TAYLOR,

Grand Junction, Nov. 8, 1906.

REPORT OF THE IRRIGATION ENGINEER.

During the year, the work has followed the outline, and it together with the accumulated results of previous years, needs to be worked up to result in a number of bulletins.

The general topic of the irrigation survey of Colorado is one which has been the constant purpose of this section of the Station for a number of years, but the scope has been such that but little can be done from year to year. The special studies which have been made in Evaporation, in Duty of Water and in the Return of Waters, have been only separate steps which when completed will close into a whole.

The valleys of the Platte, the Poudre, the Arkansas and the Rio Grande have been quite thoroughly investigated.

The most time and expense this year has been given to the investigation of the draining of the lands near Grand Junction.

Because of the Western Slope fruit investigation, this investigation seems a timely one. A great many acres of valuable land in that community have become water logged and it has been therefore a matter of great economical importance to determine the remedy. The first and most important step in prescribing has been to be sure of the diagnosis. During the year careful and complete measurements have been made over an area of many square miles including the determination of the surface and ground water in the attempt to get at the source of the water and the reason for its action in separate cases. The study is not complete but leads to some manifest conclusions. One is, that the water is used in excess, and that a united system of drainage becomes necessary.

An interesting study has been made of a water system isolated from all others and where the conditions were especially favorable for a record of the water as applied, of the acreage and the other phases of the water. In most cases, the application of water from one ditch is so complicated from the effect of the water applied from other ditches that the study has to be taken up on too large a scale to be within our means of men and apparatus. This also is being worked up. The records in meteorology have been continued as before, and now with the nearly twenty-five years' record, they have become of much value for a knowledge of the climate. These records involve an enormous amount of time and labor but they are worth the time and cost. An intelligent study of the plant life can not be made without a knowledge of the portions relating to water.

The measurements of water developing in streams has been made for a number of hundred miles. They show the continued increase in the water which returns to the streams. It indicates

that the water thus coming to the Poudre, as a specific instance, has practically doubled in the past fifteen years, and that this increase means an increase of many thousands of acres as possible from the water supply of that stream. Where the other streams of the State are also included, it means the increase of several hundred thousands of acres in the Platte Valley alone.

These measurements with further extensions relating to the mutual relation of water and crops, which is a laboratory study, long wanted to be undertaken, we desire to take up at fuller length during the coming year.

In this work, we have had the efficient help of Professor House, Mr. Trimble, Professor Lorey, and Mr. F. L. Payne, to whom much credit is due.

Respectfully submitted,
L. G. CARPENTER.

December 1, 1906.

L. G. Carpenter, Director,
Colorado Experiment Station.

Dear Sir—The months of June, July and August were spent by the Assistant Irrigation Engineer in the Grand Valley upon the investigation of the seepage problem presented in that Valley.

Headquarters were established at Grand Junction. Holes six inches in diameter and running down to water were dug one-fourth of a mile apart and running on each section line from the ditch to the river. These lines of holes cover nearly the entire valley. A line of levels was run over the holes and accurate data has been collected of the depth of the surface water throughout the entire irrigation season.

Seepage measurements were taken on the Grand Valley Canal, the High Line Canal, the Mesa County Ditch, and the Independent Ditch.

The data has all been taken but it yet remains to tabulate this data, draw the maps, write up the conclusions, and an instructive bulletin ought to be the result.

The data collected seems to point to the fact that the seepage in the valley is due to excessive application of water in irrigating the land and is not due to the seepage from the main ditch. The remedy, of course, will be more economical use of water in irrigation, and the drainage of the worst seeped places.

Respectfully submitted,
E. B. HOUSE.

REPORT OF THE CHEMIST.

To the Director:

I herewith hand you my report of the work of the Chemical Section, covering particularly the period since my last report.

The only bulletin work completed is represented by the manuscript on the extraction and refining of beeswax and some analytical work requisite to the preparation of a small bulletin on the Australian salt bush, Atriplex semibaccata, and Russian thistle hay.

My reasons for the preparation of the latter material are essentially the following: In the eastern portion of this State, where the rainfall is small and stock raising is almost the only dependable industry, it is a question of considerable importance to the people that they should have a forage plant for hay-making which will not only make a good growth with a very small rainfall, but which will also furnish a relatively good fodder. The need of such a forage plant is so badly felt in some sections that the grass, locally known as sand grass, a dry, coarse, harsh grass, Russian thistle, and the native salt bush, Atriplex Argentea, have been used for this purpose.

In Bulletin 93 I recorded some experiments with hay made from the native salt bush, Atriplex Argentea, which while it is richer in the proteids than either corn fodder, timothy hay or native hay, and would, from the standpoint of Analytical Chemistry, be considered a fairly good fodder, and this judgment would not be gainsaid by a consideration of the coefficients of digestion unless those for the crude fibre and ash, the former being very low and the latter very high, should give rise to a question in regard to its value. The results of feeding for the short period of twelve days, however, showed that it is a very poor fodder—one whose use under any circumstances would probably be attended with more evil than good.

Concerning the Russian thistle hay, I have no data except such as I have gathered from individuals who have used it, which is, as a rule, of little value. There is, however, a substantial agreement that the thistle hay is of some value, though the claim made by some that it is very good is not to be accepted, as established.

There have been times in the eastern part of the State when any fodder at all for a few days would have saved the lives of many head of stock and it is to meet the exigencies of these short periods that energetic and provident persons have resorted to the expediency of using the fodders named. It is my belief that the Australian salt bush named is worthy of consideration in this connection and will probably furnish a source of fairly good fod-

der. This seems to me to justify the publication of a short bulletin on this subject.

The work in connection with my digestion experiments, is nearly completed and would have been wholly so before this had we not had our attention diverted to other work which would not so well admit of postponement.

The study of the deterioration of farm-yard manure, under our conditions is progressing as rapidly as the subject will permit. The practical importance of this work has become very much less than it was when we began it. The practice of our ranchmen up to a few years ago was irrational and wasteful in the extreme. This work was undertaken primarily to obtain data on this subject, which are at present wholly wanting, but it was hoped that its practical bearing upon our farm practice would be to correct this wastefulness and contribute to more rational treatment of our soils. The practical results hoped for have already been largely anticipated, due to a number of reasons but probably, most largely to the monetary returns obtained by fertilizing the land to be planted to sugar beets.

We have not been able to approach the new work which we planned for the very simple reason that we have been busy all the time, having more work than our present force can get done.

In regard to the study of the changes in the water used in irrigating the meadows of our mountain districts, the composition and digestibility of the forage grown under these conditions, I have nothing other to say than I have already put in writing. The subject is not wholly peculiar to Colorado, and has been studied, but not recently, so far as I know, and not under such favorable conditions as obtain here.

The subject presents, as it appears to me, some very interesting questions pertaining both to the water and the vegetation. But aside from these chemical questions, the marked economic results obtained in feeding, in the high parks of the State, for instance in North Park, invite inquiry into their causes, for these results are wholly, or in the main, obtained by the use of the native, mountain meadow hays, without the addition of grain.

The completion of the study of the waters, surface and underground, of the San Luis Valley is also awaiting us. The work which we did on these waters some years ago ought to be repeated and extended. The study promises some very interesting results pertaining to the changes which these waters undergo, both on the surface and within the strata composing the formation of the valley.

I have done very little, practically nothing, on the subject of alkali within the past year. Considerable material has been accumulated but the importance of the subject since our people have begun to drain their lands is less than formerly; another reason why I have not prosecuted further work on the subject is that I have found the character of our alkalies to be so nearly uniform that further addition to the already considerable number of

analyses seems to be useless. This subject of late years has become of some importance in the San Luis Valley and an extension of this study in connection with that of the waters of this valley might be worth the doing, otherwise I do not see any good reason for not considering the work completed.

We have done some miscellaneous work during the year covering quite a range of subjects. Such work takes a relatively large amount of time, often wholly disproportionate to its importance.

The requests for work of this character are quite numerous and though both the President of the College and yourself answer a number of these, we have received requests for one hundred and nine analyses in the past eight months, not counting requests from other sections of the Station. These requests are mostly for analyses of soils and waters, frequently specifying that a complete, thorough, correct or reliable qualitative and quantitative analysis is desired. It is simply impossible to consider these.

If we count a complete analyses, such as is frequently specified, of a soil or water, as requiring 60 hours work and we agreed to do one-half of the work requested within the last eight months, not counting the requests from other sections of the Station, we would have 3,000 hours' work or one man's time for 377 days of eight hours each—about 15 months' continuous work, counting 26 work days to the month. The department would either have to have two assistants for this class of work should we do all that is presented, or give up our station work proper.

The same considerations apply to a certain extent to work from other departments. It is a very easy matter to make work enough to keep twice my present force busy the whole year through. The chemical section is, as I understand it, supposed to be as independent as the other departments and as much independent work is expected of it as of any of the others. At the present time, I have but one station assistant on whose time I can depend for station work. I present these facts to make it clear that the chemical department can not accept much work of a miscellaneous character and carry on systematic work of its own.

In regard to the salary of Mr. Douglass, I recommend that he receive from January 1st, 1907, a salary of $1200.00 per year. I make this recommendation because Mr. Douglass is a willing and efficient assistant and deserves this recognition of his services, which have extended over seven years.

Respectfully submitted,

WM. P. HEADDEN.

Fort Collins, Colo., Nov. 14, 1906.

REPORT OF THE AGRICULTURIST.

To the Director:

I have the honor to submit the following brief report covering the work of investigation in the Agricultural Section of the Experiment Station.

Investigations in Agronomy.—The work in this division has been reported on very fully in the supplemental reports submitted herewith, prepared by Professor Olin and Mr. Knorr. The agronomy work is sub-divided into plant breeding, or field nursery work; co-operative experiments with selected farmers in various parts of the State, and cultural, seed selection and variety tests on the station farm. The plant breeding, or nursery work, has been directly in charge of Mr. Knorr, and the results obtained have been very encouraging for the first year. In this sub-division definite results can not be expected for a number of years.

In the co-operative work with the farmers the object has been to determine to what extent the results obtained by the farmers in all parts of the State would compare with those secured by the workers on the station farm, and also to introduce new varieties into the various sections, giving the farmers of that section an opportunity to study the characteristics and utility of the various grains, grasses and roots. This work has been carried on in forty-eight of the counties in the State and embraces all the varying conditions. We are very anxious to continue and to extend this work in the future and also to co-operate with the United States Department of Agriculture in the conduct of a dry land farm at Eads, on the Missouri Pacific railroad, in the eastern port of this State.

The station work proper, as reported by Professor Olin, has been greatly enlarged and developed on the new experiment farm. This work sub-divides into investigations in the various cultural methods for the growing of roots, grains and grasses; also the amount of water required by the various crops. In variety tests a vast amount of valuable work has been undertaken. Twenty-eight of the most promising varieties of oats were grown during the past season. One of these in particular yielded at the rate of 127 bushels per acre; twenty-three varieties of wheat, seventeen varieties of barley, nine varieties of peas, three varieties of corn, twenty-four varieties of sugar beets, nine varieties of rutabagas, four varieties of mangels, six of carrots and twenty-seven varieties of alfalfa were grown. A special effort is being made to secure varieties of grain with stiff straw and rust resistant characteristics for irrigated regions. Also drouth resistant varieties for dry farming conditions, and especially hardy varieties for higher altitudes. Already the new experiment farm is taxed to

its utmost in the conduct of this work. There is special need at this time for additional land where the most promising of these varieties of grains may be grown under field conditions where sufficient quantities may be grown for general distribution and for further testing under field conditions. To this end I would respectfully urge that the eighty acres of land lying immediately to the south of the Experiment farm, belonging to Mrs. Taylor, and upon which the College now has an option, be secured without delay for this purpose. The investigations now under way in alfalfa and sugar beets are especially valuable for the conditions prevailing in this State.

Investigations in Animal Husbandry.—The investigation started last year in the wintering of range steers on various rations is still being continued and its scope enlarged. In lamb feeding by the aid of College funds and through the liberality of one of our friends we are investigating the comparative feeding value of finely cut vs. whole alfalfa hay for sheep feeding purposes.

The supplemental report of Professor Cottrell outlines some very extensive plans for investigations in pig feeding, the importance of which I am sure will appeal to your judgment, and I trust will have your earnest consideration and support.

The National Horse Breeding Experiments.—This division of our work is directly in charge of the head of the Agricultural Department, under the United States Department of Agriculture, and I have to report very encouraging progress. Last year five foals were secured from five of the mares that were in foal when purchased. These have developed into strong, thrifty colts, of a size and quality for their age that augurs well for the future success of the experiment. Of the nineteen mares in the stud bred last year, seventeen proved to be in foal, two aborted and one colt died at birth. We now have fourteen fine thrifty colts, all showing marked uniformity of characteristics and all approximately the type desired. The stables and corrals, the building of which was made possible by the special appropriation by our State Legislature two years ago, have been completed at an approximate cost of $6,000, about $4,800 of which came from the special appropriation and the remainder from College funds. As this experiment progresses and the stock multiplies, there will be urgent demands for additional sheds and paddocks. At the present time there is great need for shelter for the brood mares.

Respectfully submitted,

W. L. CARLYLE,

Agriculturist.

REPORT OF AGRONOMIST.

I take pleasure in reporting to you the work of the Agronomy Section of the Experiment Station since December 1, 1905.

Since that time our experimental grounds have been enlarged by the station gaining possession of the land purchased two years ago for experimental purposes. I have never seen better grounds for demonstration experiments than the new Experiment Farm presents. The soil, however, is not in good mechanical condition, and we shall plan our crop work to bring it into better tilth. The work of this section is divided as follows:

1. Co-operative work over the State with good representative farmers. We are testing several crops in this way to determine their adaptability to that particular region.

a. Hardy types of winter wheat in southwest Colorado.

b. Desirable native and cultivated grasses for improving native meadows in various parts of the State.

c. The best milling type of durum wheat in 39 of the 59 counties of the State on non-irrigated lands, to determine areas adapted and to what extent it is drought resistant.

d. High altitude grains with the view of pushing the grain belt 1,000 feet nearer snow line.

e. Vetches for forage in the higher altitudes where other cultivated forage has not been successfully grown.

f. Varieties of corn to determine best type for the few regions which are successfully growing corn.

g. Testing crops best adapted for North Park—a continuation of last year's work. This should be carried on for at least another season.

2. Experiments with Mr. Blinn, station agent at Rocky Ford. The work with Mr. Blinn is the development of desirable seed producing hardy, disease resistant types of alfalfa for the Arkansas Valley region. The work is so interesting and shows such a satisfactory beginning that I wish Mr. Blinn to report specifically upon the progress of this work. I sent seed from various sources and he has done exceptionally well with it.

3. Eperiments at the home station. The following outline gives a summary of our field experiments now under way:

a. Development of a Colorado type of durum wheat, of known milling value, adapted for certain non-irrigated lands.

b. Development of the earliest maturing types of wheat, barley and oats, of reasonably good yielding power and of good quality for the higher altitudes.

c. Development of a barley of high feeding value adapted for the irrigated lands and another type having drought resistant power adapted to certain non-irrigated lands, the object being to substitute barley for corn in finishing certain classes of live stock for market.

d. Development of distinct types of alfalfa well adapted to Western conditions which show disease resistant power, hardiness and carry a high percentage of leaf to stem, increasing forage value. This is so important a work that the alfalfa expert of the Nation—Mr. J. M. Westgate—has joined with me in this work. We have our alfalfa nursery south of Agricultural hall and expect to make this breeding of alfalfa one of the most important divisions of the agronomy work.

e. Development of a malting type of barley adapted to the irrigated lands of the foot hills and mountain mesa regions of Colorado.

f. Development of beardless types of drouth resistant spring and winter wheats of superior milling quality.

g. Experiments to improve cultural methods in beet culture, reduce cost of growing the crop and increase yield and quality of beets.

h. Development of good yielding stock roots well adapted to our climatic conditions. We should grow more roots for our live stock.

4. Correspondence Work. The correspondence work in agronomy has nearly doubled during the year, and I find it takes a considerable portion of my time. I believe this is an important part of the station work that should be carefully and thoroughly done.

5. Publications. During the year our section has issued two station bulletins and two press bulletins.

At the beginning of the year, Mr. A. H. Danielson, the assistant agronomist, left the station work to engage in farming operations for himself, and Mr. Knorr was called to the work. Mr. Knorr had completed his agricultural work under the direct supervision of Prof. W. M. Hays, now Assistant Secretary of Agriculture at Washington. Mr. Knorr was in the junior year of university work in Minnesota and on coming here took up our junior work and completes our regular agricultural course this school year. He is efficient, industrious and careful in his work and is proving a most competent helper in station work.

Respectfully submitted,

W. H. OLIN,

Agronomist.

November 15, 1906.

REPORT OF CROP NURSERY WORK.

The breeding of our field crops to secure increased yields, and plants or grains that are higher in food value than those we now have is one of the many problems that must be worked out by the Experiment Station; the start made at this Station bids fair to success along this line of work; it will be seen, however, that this work is hampered to an extent through the lack of apparatus and funds.

The growth of the nursery and the results obtained this year are as satisfactory as could be expected under the conditions under which we worked. The land on which the nursery was located was in sugar beets the previous year; when the beets were removed the ground was wet; this packed the soil and left it in a poor physical condition; later on the pasturing of the tops by cattle again packed the soil; the scattering of manure by these cattle made the field on the whole very uneven, and in a very poor condition for experimental purposes as in some instances the results are hardly comparable.

In the spring of 1906, 155 nursery stocks of wheat, oats and barley were selected from the more than 500 stocks that were grown in 1905; the selections were based upon yield, and quality of the grain. Of the 155 stocks grown, 104 were wheat; these were again divided into 39 varieties of straight selections, and 65 hybrids. At harvest time 46 of the wheat stocks were discarded; 6 stocks were selected for increase in 1907, among which 4 of them are crosses of common and durum wheat, hence a beardless durum type; from the remaining 52 stocks individual selections were made to be used as mother plants in 1907.

Of the barleys twenty-three selections were made in the spring of 1906; of these fifteen stocks were discarded; some of those that were retained promise to be varieties of exceptional merit.

The oats did remarkably well; of the twenty-eight stocks planted only eleven were discarded; the basis of selection for this grain is yield, quality, ability to stand, and rust resistance.

The work with alfalfa is perhaps as promising as that with the grains; the alfalfa nursery contains twenty-six stocks, most of which are from as many different parts of the globe; the first object is to find which of these are best adapted to Colorado conditions; in the spring of 1907, after ascertaining which of these varieties can best stand the winter, individual plant selections will be made. The breeding work with alfalfa is a fairly new proposition; the problems presented along this line are numerous, but the first of these that require our attention are: increased yield; disease resistance; increased leafiness—most of our pres-

ent varieties of alfalfa yield a higher per cent. of stem than leaf, hence a loss in feeding value..

It is hoped that in the coming year we may be able to extend our breeding work to some of the native grasses and other forage plants. All of this work is very slow and painstaking, but if nothing intervenes we may be able to show some results of plant breeding work in less than two years hence.

Respectfully submitted,

F. KNORR,
Assistant Agronomist.

Fort Collins, Colo., Nov. 13, 1906.

REPORT OF THE ANIMAL HUSBANDMAN.

I herewith submit a report of my work in Animal Husbandry and a statement of plans and needs for the future:

I began September 1st, 1906, and by mutual agreement the Animal Husbandry work was divided—you retaining all work with horses and pure bred stock and assigning to me charge of all lines of feeding. October 1st, you engaged W. H. Riddell, a graduate of this College, Class of 1906, as my Assistant.

I found an experiment under way with steers to test the difference between keeping beef cattle on the range from birth until marketed at three years of age and of feeding them through the winters and running them on the range during the summers. There are good yards and sheds for handling the cattle in this test. With this exception I found no stock nor equipment available for feeding work.

A plan for feeding experiments with hogs was submitted to the Director of the Experiment Station and he stated that all funds under his control were needed for experiments under way and that no money could be spared then for feeding tests. The matter was submitted to the Executive Committee of the Board, and they made an allowance from College funds sufficient to provide for yards for feeding 250 lambs and for sheds, yards and hogs for a feeding test with 100 hogs.

At this date we are feeding 250 lambs to ascertain if it will be profitable to cut alfalfa hay when it is fed to fattening lambs. The lambs were furnished by the Wood Live Stock Co., Spencer, Idaho, who pays us for the gains we put on. The yards and sheds are ready for feeding 100 hogs, the experiments are planned and feeding will be started as soon as the hogs can be purchased at a reasonable price.

The lamb feeders have demonstrated the advantages of this State for producing a high quality of mutton profitably and Colorado feeds and conditions are as well adapted for feeding all other classes of farm animals as for sheep. The Animal Husbandry Department of the Agricultural College should demonstrate this on a commercial scale and when we do so, the work will not only enable stockmen now in the State to increase their profits but it will induce stockmen with capital to come in large numbers to this State to secure the special advantages which Colorado conditions furnish.

I urge that at the earliest possible date equipment for this work be provided as follows:

Sheep. Ten feeding yards with feed boxes and water supply, each yard for 100 head, scales for weighing sheep and feed and storage for grain. This equipment will cost about $900.00 and it

is probable that we can arrange to fatten the sheep and lambs needed for experiments, getting paid by the pound for the gains we put on and not be obliged to have the funds with which to buy the animals.

Our first work in feeding lambs and sheep should be to find methods that will secure greater gains for feed consumed and profitable ways of using a greater proportion of Colorado grown feeds. This should be followed by tests to determine the lines of breeding that will produce the most profitable feeder having a carcass with the greatest proportion of high priced cuts.

Hogs. Eighty-five per cent. of the hogs slaughtered in Colorado are shipped in from Kansas and Nebraska, yet Colorado feeds are particularly adapted for producing pork of the best quality and at less cost than pork is generally produced in the corn belt.

Denmark spent large sums in finding what feed would produce bacon having the choicest flavor and found it to be barley; England pays $18,000,000 a year for barley-fed bacon from Denmark and pays a much higher price per pound for it than for the best grade of American corn-fed bacon. Barley is the surest grain crop grown in Colorado, yielding well under both dry land farming and irrigation, and Colorado feeders have alfalfa and peas to feed with it, both of which produce choice flavor in pork at low cost.

We should demonstrate on a large scale just what these and other Colorado hog feeds will do and induce Colorado stockmen to produce all the pork needed in the State and that demanded both by the high price trade in eastern United States and in Europe.

I recommend the securing of 100 sows and 8 boars, 100 farrowing sheds for individual sows, yards for 100 sows and their pigs, fattening sheds for 500 pigs and the division of 50 acres of land west of the farm machinery sheds into ten five-acre lots for hogs. This plan will cost about $6,500 and by raising two litters a year we can feed and market 1,000 hogs annually.

We should find the best methods and feeds for producing pork cheaply, then in co-operation with the packers determine ways of feeding and curing to produce the choicest flavored products; when we have secured both these, we should send our College fed pork to Europe and find what modifications in feeding and curing will be desirable to fill the requirements of the highest priced trade there.

Poultry. One million and a half dollars worth of poultry were shipped into Colorado the past year and the entire yearly poultry products marketed in the State will not supply Denver alone for more than sixty days.

Few states have as favorable conditions as Colorado for profitable poultry production and the State should not only produce all the poultry and eggs it needs but should ship to other states several million dollars worth annually.

The Agricultural College should take hold of this industry and push it. We should keep 1,000 hens and I recommend 20 colony houses, each for 40 hens, 20 colony houses each for 10 hens, an incubator house for 20 100-egg incubators, brooding facilities for 5,000 chicks and a fattening house.

The building equipment needed to start this work will cost about $2,500 and I believe the poultrymen will aid us with donations of a sufficient number of fowls. With such an equipment we could determine the best methods of breeding, rearing and handling poultry in Colorado and could establish a practical poultry school. This work will interest and benefit financially more people than any other line we can take up.

Beef Cattle. Colorado feeds are particularly adapted for the production of beef on growing animals. We need ten feeding yards with sheds, racks, feed boxes and water supply each for twenty head and I believe the work we should first undertake should be the testing of Colorado feeds in the production of baby beef, taking calves off the range at weaning time and fattening them ready for market when twelve to eighteen months of age.

Dairy Cattle. The best work that we could do at present with dairy cattle would be to take 20 ordinary cows off the range and develop them as quickly as possible a dairy herd of twenty cows that will produce per cow per year 8,000 pounds of milk and 400 pounds of butter.

Respectfully submitted,

H. M. COTTRELL,
Animal Husbandman.

November 7, 1906.

REPORT OF THE VETERINARIAN.

To the Director:

The claim is made, and I believe fully substantiated, that tuberculosis and asthma in the human family are greatly benefited by the climatic conditions found in Colorado. It is also true that not one of the great animal scourges has ever seriously threatened our State, and our live stock is to-day as healthy as can be found anywhere.

These facts are no doubt responsible for the sweeping claim often made and entirely unwarranted that tuberculosis, hog cholera, and other contagious diseases do not find a natural habitat under the climatic conditions found in the arid West. The danger is that we become overzealous in our claims in this respect and relax our vigilance in necessary quarantine and sanitary measures.

As college veterinarian, I am frequently called to various parts of the State to investigate outbreaks of supposedly contagious diseases among all kinds of domesticated animals. This field work is not always directly connected with my duties as veterinarian to the Experiment Station. It serves, however, to keep me in touch with the existing live stock conditions throughout the State, and which is indispensible to my work in every way.

The most important diseases named casually in the order of their economic significance are as follows: Tuberculosis, mostly in cattle and swine; poisonous plants, largely on the open range; mange in cattle in western half of State; strangles in young horses all over the State; scabus in sheep; black leg and anthrax; contagious abortion in cattle; parasite diseases; calf scours; horse typhoid; calf diphtheria; hog cholera and glanders.

Poisonous plants, horse typhoid, and tuberculosis have been the subjects of special investigation since my last report.

LOCO WEED INVESTIGATION.

The investigation of loco weeds has progressed satisfactorily. We were fortunate in securing the same pastures and buildings at Hugo that served us so well last year. In addition to the station at Hugo, the Department of Agriculture saw fit to start another station without our co-operation at Woodland Park, on the Divide.

By mutual agreement it was decided to withhold report on this work until the investigation is completed, or at least far enough advanced to warrant positive assertions. Although a

number of the experiment animals (horses and cattle) at Hugo are badly locoed, there will probably be at least twenty live over until spring.

The work thus far has brought to light some of the hidden mysteries surrounding this perplexing problem, and it is hoped that it will result in something that will be of real economic value to the live stock industry, as well as a valuable contribution to science.

The last part of the work, yet to be done, is of vastly more importance. It is not sufficient to simply know the specific cause of the locoed conditions. The question always to the front is, What are we going to do about it? Unless we are able to suggest effective prophylactic and remedial measures, it will have very little if any economic value.

Bulletin No. 113 on "Larkspur and Other Poisonous Plants" was published early in the summer. This was an illustrated bulletin, gotten out especially for the farmers and stockmen, and containing a summary of what is known about Western poison weeds, with a patent suggestion as to the best means of contending with them.

HORSE TYPHOID.

This disease, it seems, has existed in the State for several years. In the last two years it has greatly increased, and in the vicinity of Colorado Springs and on the Western Slope has caused the death of a large number of horses. It is so entirely unlike any disease known to horsemen and so little understood by veterinarians that the appellation "No named disease" seems quite appropriate. The symptoms are much like typhoid fever in the human. In many respects it is like malarial fever, swamp fever, or the oriental disease, surra. The victims practically all die in from three weeks to as many months.

In Wyoming, where the disease has assumed more serious proportions, investigation revealed the presence of large numbers of parasites (Strongulus armatus) in the large intestines. This led to the assumption that they were in all probability the direct cause of the malady. Our work with the disease thus far has not tended to substantiate this claim. In most cases it is found in horses that graze on bottom lands. In exceptional cases, however, the disease has developed in horses stabled and furnished with apparently pure water. The symptoms all point to the presence of a blood parasite, but so far we have not been able to find it. The etiological factor in this case, as in many others, can only be worked out in the laboratory. Our laboratory equipment is so meager as to make even a satisfactory blood count impossible.

A summary of our work with tuberculosis in the college herd, for the past six years, is as follows:

PER CENT. NATIVE TO COLORADO.

Year	Tested	Responded	Reacted	Per Cent.	Kept Over
1900	9	5	55.5	60	2
1901	27	7	25.8	00	5
1902	36	12	33 1-3	33 1-3	8
1903	50	7	14	14.3	0
1906	29	5	10.4	25	2

Sixty-three and six-tenths per cent of cattle tested were natives of Colorado; 25 per cent of all cattle responding were native Colorado cattle.

Test in 1902 included six animals that reacted in 1901.

Test in 1903 included eight animals that reacted in 1902.

Test in 1906 included no animals that reacted in 1903.

One animal responding still remains on the farm.

Leaving out the animals each year that had previously responded to test, the following results were obtained:

Year	Tested	Reacted	Per Cent. Reacted
1900	9	5	55.5
1901	27	7	25.8
1902	29	5	10.3
1903	42	0	00
1906	29	5	17.3

This table is especially interesting and instructive as showing that while more than one-half of the cattle tested for tuberculosis were natives to Colorado, yet three-fourths of the animals diseased were imported.

While 11.8 per cent of all native cattle tested on the college farm in the last six years have been proven tuberculous, nearly one-half of all cattle brought from outside the State on to the college farm have responded to the test and were disposed of accordingly.

Respectfully submitted,

GEO. H. GLOVER.

November 13, 1906.

REPORT OF THE ARKANSAS VALLEY FIELD AGENT.

To the Director:

As outlined, the work in the Arkansas valley has been pursued under three general subjects, alfalfa, beets and cantaloupes.

Under the subject of alfalfa, there has been two objects in view: First, the improvement of alfalfa by a systematic seed selection from a nursery of individual plants, and second, the investigation of the methods employed by the most successful alfalfa seed producers to develop the essential conditions that are necessary to a good yield of alfalfa seed under the conditions of irrigation in Colorado.

During the past season our alfalfa seed nursery was enlarged by the addition of twelve rows, sown with seed selected the previous season. A careful observation of the individual plants in the nursery was made and this study revealed the fact that there was a wide variation in individuals which had grown under the same conditions, and that this variation in many instances was in the line of marked improvement, for example, the general yield of seed in the nursery was poor, yet a few individual plants "set" remarkably heavy yields of seed, while many adjacent plants, apparently as vigorous, were almost barren of seed production.

As marked lines of variation were also noted in the matter of desirable hay producing qualities, disease resistance, and possibly the character of the bloom for honey yield. From these desirable variations the seed of sixteen individual plants was saved separately to continue the work in seed selection.

The second topic, the investigation of alfalfa seed production has occupied but little time as yet, but it is the plan during the next two months, while the alfalfa seed threshing is in progress, to visit the most successful seed growers and ascertain their theories and methods relative to alfalfa seed production, and collect as much data as possible for further study, and solve this important question.

Beets.—Under this topic we have continued the efforts to develop a disease-resisting beet. We have now about fifty pounds of seed, the second generation of seed produced since the selection of beets from "curly top"-affected fields in 1903. Since that year the trouble has not appeared in Colorado, and in order to test the merits of our selection at this time, we have sent to Dr. C. O. Townsend, of the Department of Agriculture, about twenty-five pounds of this seed, he agreeing to send it out to portions of California and Utah, where the trouble occurs to some extent

each year, and will report to us if the seed possesses any inherent resistant qualities.

In this connection we have gained considerable knowledge and information relative to the problem of beet seed growing, the methods and conditions required for securing a yield of beet seed; this data might be of value if commercial beet seed growing should be undertaken in the State.

The study of cultural methods for sugar beets, that was outlined, has not been taken up to much extent as yet. It is planned, however, to begin the work during the winter by making a digest, if possible, from the field books of the several beet sugar factory companies.

We have received some encouragement from some of the officials for such a plan of study.

Cantaloupes.—This subject has required rather close attention through the summer. The work of developing a rust resisting cantaloupe was continued on a half-acre plat, which for four seasons had produced cantaloupes badly affected with rust, the idea being to develop the quality in as adverse conditions as possible, consequently irrigation was applied in excess to favor the development of the fungus. The plat planted with the seed of nine individual melons planted in rows each one separate, these melons were from the most resistant plants found in 1905.

One row was planted as a check row, with seed from a very perfect melon, but from a field that had not been selected for rust resistance. The plat developed nicely without rust until about August 15; the season was characterized by cool nights and frequent rains and heavy dews, and in July the rust spots appeared on all the early melons, and when the first picking began, about August 10, the fields were getting brown with rust, as was also the check row in the rust resistant plat, while the other rows were comparatively free from rust, some of the rows revealed more rust resistance than others. The seed from the most resistant plants in 1905 were producing this year, also, the most resistant plants.

When the rust had developed to some extent on the plat which was at least ten days later than any field otherwise under equal conditions, the plat was carefully studied, and over one hundred resistant plants were staked with a number, and each day as the ripe melons were gathered they were marked with the number of the hill and the seed saved separately and a description made of the qualities of each melon.

The last of September the numbered hills were gone over and notes taken of their rusted condition, and this revealed that a few of the whole number of resistant plants had remained resistant later than others, and now it is possible to select by the number from several hundred melons, saved separately, the best melons from these most resistant hills, to further develop this valuable trait.

Careful consideration and a great deal of time was devoted to selecting melons with a view to improve their keeping qualities, as well as flavor and all the qualities desirable in a perfect cantaloupe.

The question of the fertilization of the flower and the crossing of varieties was carefully studied.

A comparative test of a list of foreign varieties received from Mr. A. J. Peters, of the Department of Agriculture, was made. Many of this list failed to germinate, but of those that did nothing desirable for home or market use developed.

Some investigational work in regard to the life history of the melon louse and means of combatting the louse were taken up in co-operation and under the direction of Prof. C. P. Gillette.

This constitutes a general review of the work of the season.

The investigation of the development of the cantaloupe industry as outlined has been submitted and published as Bulletin 108.

Yours truly,

PHILO K. BLINN.

November 1, 1906.

REPORT OF THE PLAINS FARM.

To the Director:

I desire to submit the following report for the year 1906, of work done at the Experimental Sub-Station of the Plains.

On September 22, 1905, there was 10½ acres of Turkey red wheat sown on land that was all plowed in the month of May and packed with a sub-surface packer. Eight acres of this land was planted to corn on May 15, the other 2½ acres rested until the wheat was sown, but was worked after each rain, as near the same as the corn as possible, storing the moisture of 1905. On the last day of August the eight acres of corn was cut, yielding 24 bushels to the acre, this land was then disked and harrowed, receiving this much more work than the land that rested. The wheat was sown crosswise of the two pieces, one bushel to the acre, and harrowed three times during the months of April and May; the 2½ acres was cut July 5. While that on the corn ground was not cut until July 10, the piece where the moisture was stored yielded a little over 44 bushels to the acre, while the other piece made 25 bushels to the acre.

There was sown on April 6 five acres of macaroni wheat, which yielded 17 bushels to the acre.

On April 7 there was sown five acres of side oats, sown 34½ pounds to the acre, and cut July 27, yielding 29 bushels to the acre.

There was six acres of corn planted on May 14, which yielded 25 bushels to the acre.

There was some slender wheat grass sown, which gives very fair promise, and a variety of other grasses, of which the Bromis Inermis seems to give the best results.

There was a garden of general character and everything was raised in abundance. The potato crop was unusually good. The trees have done quite well in growth. The cherry crop was good, and plum crop fair. The apple crop was light, the trees were not sprayed, as we had had no occasion to do so heretofore, but this year we were bothered with the worms. The apples blew off very badly and were quite small in size. The peaches have done well, and we had some very fine peaches. The apricot trees were loaded almost to breaking down with fruit, the quality being excellent.

J. B. ROBERTSON,
In Charge.

Cheyenne Wells, Colorado, December 10, 1906.